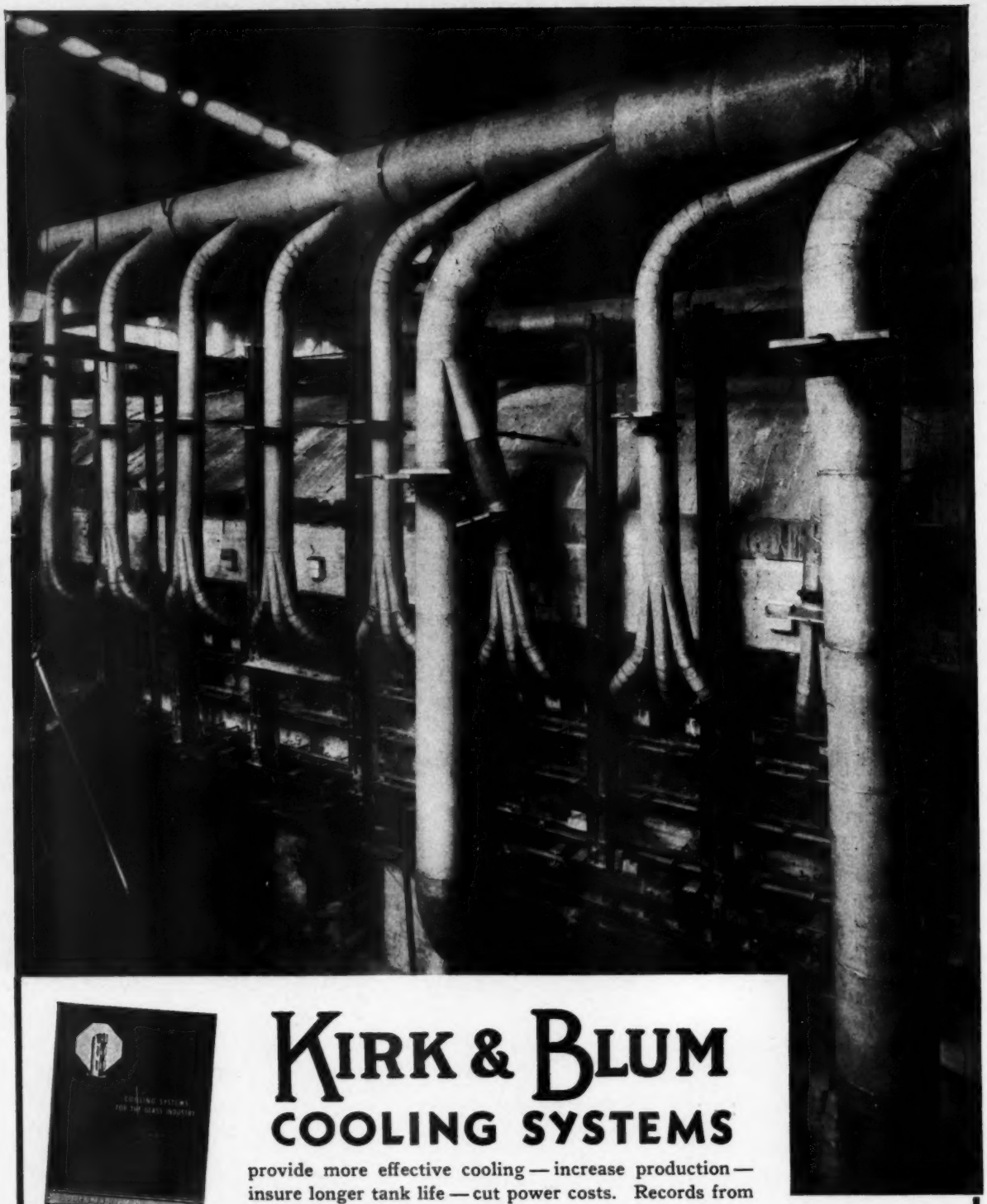
the glass industry



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the glass industry

Devoted to glass technology, engineering, material and glass factory equipment and operation

PUBLISHED AT 11 WEST 42ND STREET, NEW YORK, N. Y., BY OGDEN-WATNEY PUBLISHERS, INC.

JOHN T. OGDEN, Editor and Publisher — CYRIL B. DELGADO, Advertising Manager

F. E. BARDROF, Associate Editor — J. W. CONROW & CO., Pacific Coast Representative, Los Angeles

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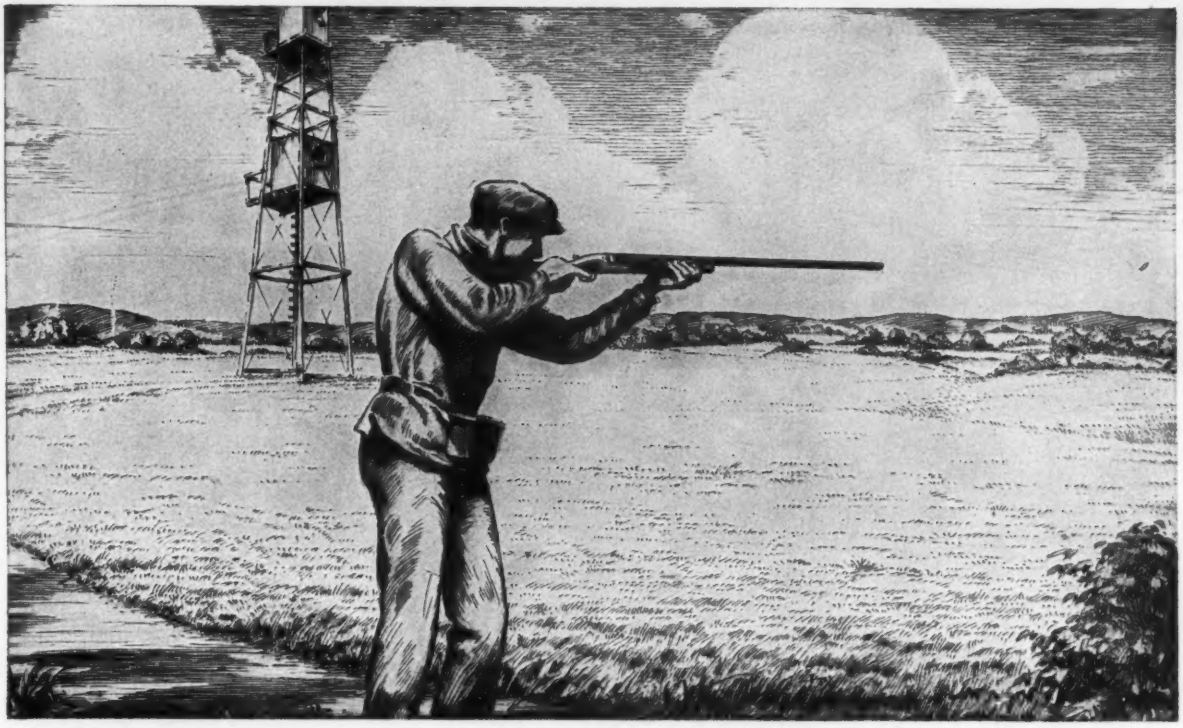
THE GLASS INDUSTRY, Vol. 20, No. 12, December, 1939. Published monthly by Ogden-Watney Publishers, Inc., at 11 West 42nd St., New York, N. Y. Subscription $3.00 a year. Foreign $4.00. Single copies, 25 cents domestic, 35 cents foreign. Issues over three months old, 50 cents. Entered as second-class matter, Aug. 10, 1921, at the Post Office at New York, N. Y., under the act of March 3, 1879.

INTERESTING USES OF ALKALIES



A Vital Step In The Manufacture Of Smokeless Powder

Smokeless nitrocellulose powder has largely replaced the black potassium nitrate powders for shotgun shells and rifle cartridges. In the preparation of nitrocellulose for this purpose, caustic soda plays a vital part. Before the cellulose can be converted into its nitro compound the fats and oils from the raw cotton are removed by the use of caustic soda in the ratio of about 2% to the weight of the raw cotton.

Because the function of alkalies in manufacturing industries is seldom recognized in the finished product, the average layman has little conception of the tremendous tonnage of caustic soda, soda ash, liquid chlorine and bicarbonate of soda used in manufacturing such important commodities as chemicals, paper, soap, textiles, glass, foods and drugs. Neither does he realize how numerous and how varied are the uses made of these alkalies. Some of the more or less obscure and minor uses have been depicted in this series of advertisements here concluded.

We have taken this novel way of bringing the name COLUMBIA to the attention of executives, technicians and purchasing heads with the hope that the high quality of COLUMBIA products and the dependability of COLUMBIA service will be remembered through the year and years that lie ahead.

We shall be glad to send you free of charge a large size reproduction of above illustration, "The Skeet Shooter" suitable for framing, if requested on business letterhead and naming magazine in which you saw this advertisement.

COLUMBIA

SODA ASH • CAUSTIC SODA • SODIUM BICARBONATE • • •
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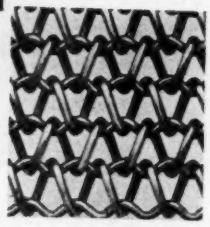
A Run of attractive Beverage Bottles on a modern decorating lehr.

Close-up photo of Balanced Mesh Belt, showing the alternate spiral construction and crimped wire connection which assure straight travel.



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Cambridge Belt Construction

TO ASSIST IN THE

Efficient...Economical Operation

OF YOUR DECORATING LEHR . . .

TODAY, in many plants throughout the country, Cambridge Lehr Belts are steadily building business and customer satisfaction. Here's how — Progressive dairies and bottling plants are more and more realizing that a distinctive inscription fused directly with the glass helps build business, adds to his prestige, identifies his product.

Constant vigilance by Cambridge engineers is your assurance of the best belt construction available today. Regardless of whether your choice is a heavier belt, woven of carbon steel; or a lighter belt, woven of low chrome alloy; Cambridge has a belt construction to meet your needs efficiently and economically. Call in our nearest sales engineer— he will be glad to assist you in selecting the best belt suited to your installation.

CAMBRIDGE WIRE CLOTH CO.

CAMBRIDGE, MARYLAND

Boston - New York - Baltimore - Pittsburgh - Detroit - Chicago - San Francisco - New Orleans

You don't know the game until YOU'VE PLAYED IT

● There's more to glass colors than you can find in a book, too. ●

A handbook may tell you the technique of getting from one end of the field to the other—but you never really *know* how it's done until you've done a bit of broken field running yourself.

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The technologists in our laboratory realize the importance of constant research, and make use of every scientific means to find facts about Drakenfeld colors and chemicals that will make your production easier, more economical.

But, they also know that laboratory knowledge must be backed up by the human experience that comes only of actual work in the field. It's this "know-how," this ability to predict results on the basis of what they've seen happen in lehrs and spraying rooms, that gives added importance to Drakenfeld research.

We've been playing the game for over seventy years, and though we always keep our laboratory eye on the future, you'll find that the rich experience we've gained in the past will be equally helpful to you in ironing out your production problems.

When we say, then, that the Drakenfeld technologists will be glad to help you without obligation, we also mean that they'll be able to give you latest laboratory findings—*plus* the practical knowledge that comes of long experience. Why not drop us a note the next time you run into a production problem that looks like a tough one?

The BRICK of the Year

"Jack of All Trades"

TYSON is a general purpose fire brick—yet it serves each individual purpose as adequately as if especially prepared for the job.

TYSON high heat duty fire brick originates with selected high-quality Olive Hill, Kentucky, fire clays . . . is made by a vacuum-pressed process with controlled grain sizing . . . of uniform size and density . . . fires to higher than average temperatures . . . gives excellent resistance to spalling, load deformation and slag attack.

TYSON'S versatility is coupled with preferred quality—but it costs no more than ordinary fire brick. Just might as well specify TYSON and have the advantages of prolonged life and lower operating expense.

Its efficiency will approve your buying judgment

TYSON DASH, a companion brick, is especially designed for checker service in glass tanks and open hearth furnaces. Its high density and slag resistance are aiding the acceptance of this brick throughout the country.

TIGER STEEL is a de-aired stiff-mud repressed high heat duty fire brick used in foundries and wherever abrasion resistance is the most important factor.

TIGER, a moderate heat duty brick, is excellent for back-up work, flue linings, stacks, etc.

TAYCO REFRACTORY CEMENT is an excellent high temperature bonding mortar with many possible uses.

TAYCO 40 CEMENT is that special mortar for silica refractories having unusual working properties, and important in reducing spalling.

THE CHAS. TAYLOR SONS COMPANY

Manufacturers of P. B. Sillimanite and Fire Clay Refractories

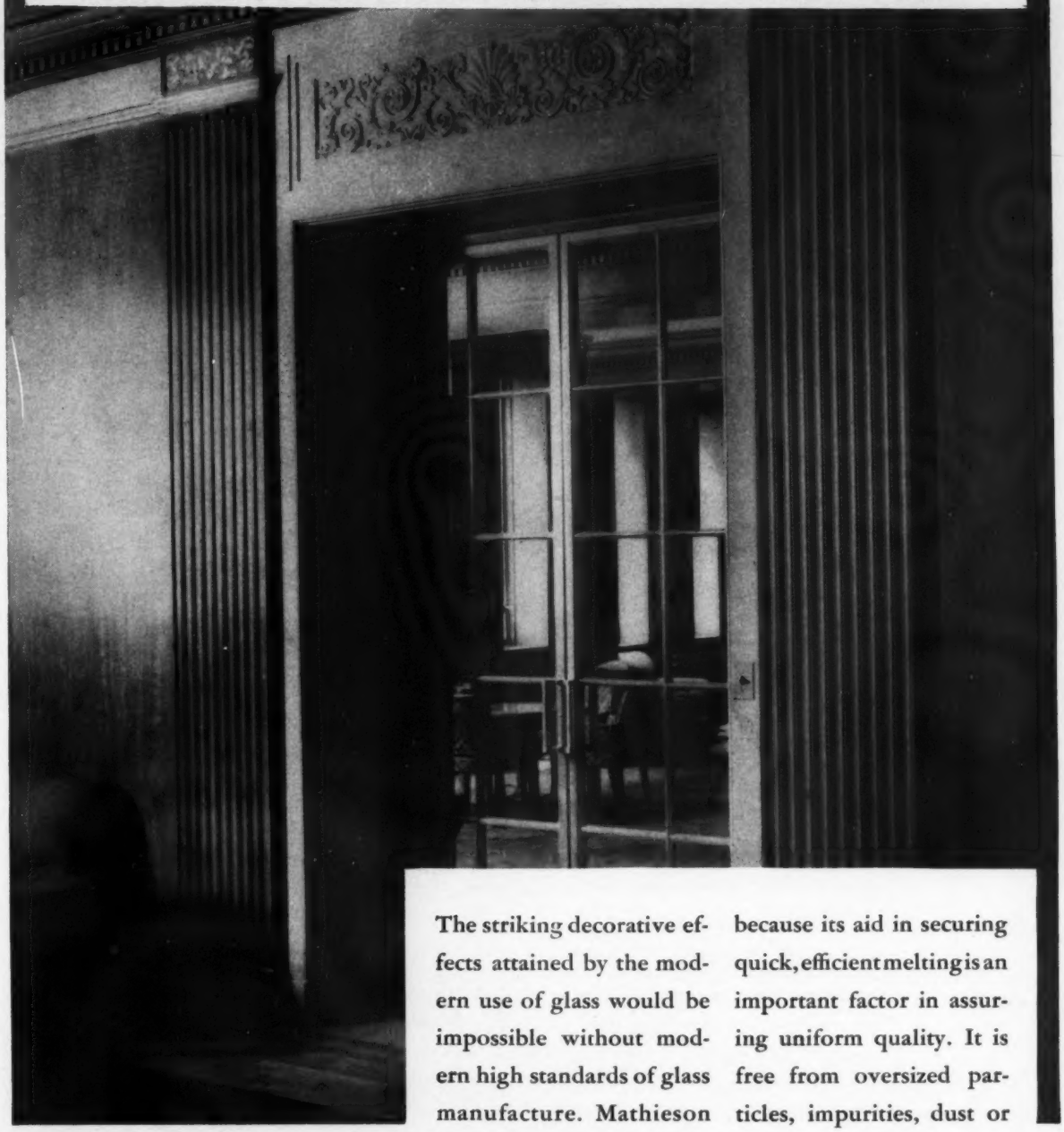
Cincinnati, Ohio

All P. B. Sillimanite made by The Chas. Taylor Sons Company bears this trade-mark—your guarantee of satisfaction.

TAYLOR P. B. SILLIMANITE

PIONEERS IN REFRACTORY PROGRESS WITH 75 YEARS EXPERIENCE

This beautiful doorway, entrance to the Social Room in the new building of the Mellon Institute, is made entirely of mirrors set in an aluminum framework, with carved Botticini marble lintel.



The striking decorative effects attained by the modern use of glass would be impossible without modern high standards of glass manufacture. Mathieson Dense Soda Ash is popular with modern glass makers because its aid in securing quick, efficient melting is an important factor in assuring uniform quality. It is free from oversized particles, impurities, dust or other foreign matter. Let us quote on your requirements.

Mathieson Dense Soda Ash

THE MATHIESON ALKALI WORKS (INC.) 60 E. 42ND ST., NEW YORK, N. Y.

SODA ASH . . . CAUSTIC SODA . . . BICARBONATE OF SODA . . . LIQUID CHLORINE . . . BLEACHING POWDER . . . HTH PRODUCTS . . . AMMONIA, ANHYDROUS and AQUA . . . FUSED ALKALI PRODUCTS . . . CCH (INDUSTRIAL HYPOCHLORITE) . . . DRY ICE . . . CARBONIC GAS

I'd give a tonsil for a tenor

Three men singing may present some harmony, but it takes a fourth man to make a quartet.

Quartets are usually preferred because they involve a better balance of voice. Four men instead of three give a sense of completeness, with nothing left out. There is more body and fullness and a better quality of tone. The "fourth" man completes the cycle of harmony.

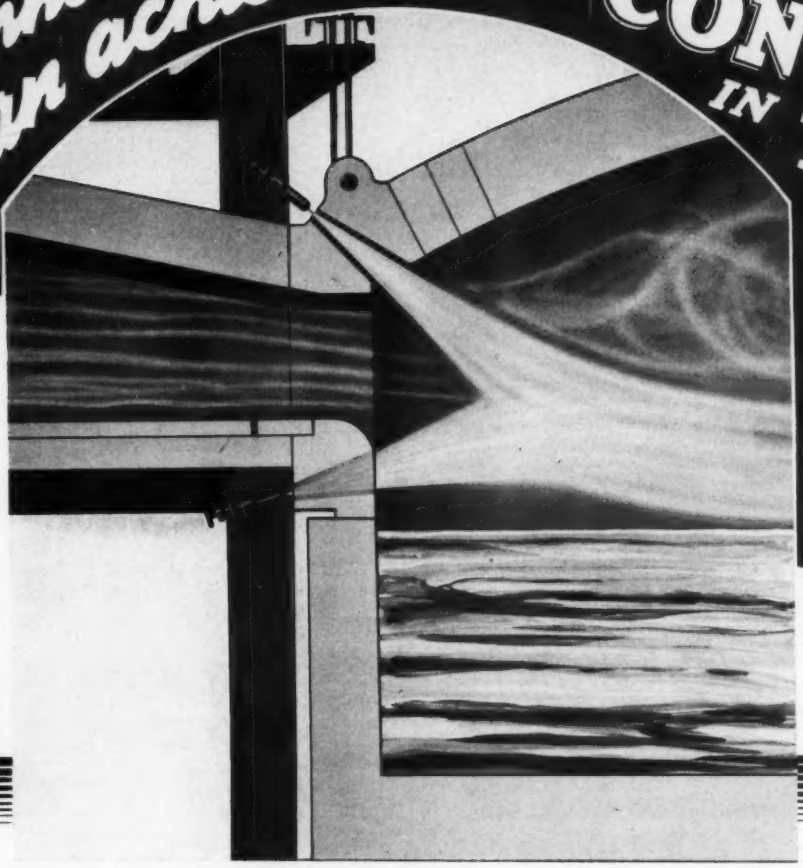
Whether our business is the making of harmony or the manufacture of glass, there is an analogy. In glassmaking it is possible to use just three ingredients: soda, lime and silica—but it is that "fourth"—Borax—that does the complete and satisfactory job. Borax gives glass brilliance—clarity—and extra strength, and actually cuts down on production costs . . . The glass manufacturer saves in both fuel and refractory costs, for the fining and fluxing properties enable melting at lower temperatures.

Borax is that important "fourth"—that minor constituent of major importance—which helps you make better glass more economically.

PACIFIC COAST BORAX COMPANY

DEPARTMENT G • 51 MADISON AVENUE • NEW YORK

Announcing an achievement in CLOSE CONTROL IN Tank Firing WITH OIL



● New high efficiency in oil firing has been attained by combining with the Toledo below port burners, a third control burner located above the port.

● These burners respond to wide adjustment adapting them closely to varying conditions and melting loads. A clean flame is obtained closely resembling that of natural gas.

● The flame is controllable as to length and breadth, giving full coverage of the surface of the glass. There is no fire in the crown of the furnace. Efficient operation at very low pressure is possible. This prevents short-circuiting of the flame and definitely increases the life of the checkers.

● The lower burner block is built in jack-arch formation supported independent of the flux. The upper burner block is also of jack-arch design and is independently supported to take care of expansion and contraction.

● In repeated tests this advanced method of oil firing has produced glass of very high quality with considerably less fuel and materially reduced maintenance cost. It is adaptable to side port or end port furnaces.

TOLEDO ENGINEERING Company

GLASS MELTING *and* MANUFACTURING EQUIPMENT

EASTERN OFFICE 220 E. LEXINGTON ST. BALTIMORE MD. • • • 958 Wall St. TOLEDO, O.

Better than Ever Equipped To Improve Quality and Lower Cost

★ "The progress that American manufacturers have made in the production of quality ware at moderate prices should maintain and possibly increase the saleability of these products in foreign markets."

★ "Another development of note in the glass export trade has been the almost continuous rise in sales of tableware — largely machine-made lines."

From *"Commerce Reports"* of Aug. 26, 1939, Published by United States Bureau of Foreign and Domestic Commerce.

HARTFORD-EMPIRE inventions, developments, equipment and engineering service have long been among the most important contributions toward making this possible. . . . Its experimental glass factory, shown here, has recently been greatly enlarged and combined with new laboratories of the most modern type. • • • • •

HARTFORD-EMPIRE COMPANY

HARTFORD CONNECTICUT

THE GLASS INDUSTRY

VOLUME 20, NUMBER 12, DECEMBER, 1939

A SYMPOSIUM ON TEMPERATURE
ITS MEASUREMENT AND CONTROL IN SCIENCE, INDUSTRY

Under the above title one hundred and twenty-five papers were presented at a meeting at the Hotel Pennsylvania, New York, on November 2-4, sponsored by the American Institute of Physics in conjunction with the National Bureau of Standards, the National Research Council and twelve technical Societies, among which was the American Ceramic Society and the American Society for Testing Materials. Over 500 technical men were in attendance, representing practically every major industry in the United States, including glass. As a number of papers are of interest to readers of this publication, THE GLASS INDUSTRY has requested Nelson W. Taylor, head of the Department of Ceramics, Pennsylvania State College and chairman of the Glass Division of the American Ceramic Society, to report his impression of the meeting for its readers. This he has done in the paragraphs that follow. Dr. Taylor's report is followed by summaries prepared by GLASS INDUSTRY staff reporters.

At the general session H. T. Wensel of the National Bureau of Standards discussed Temperatures and Temperature Scales, in which he showed that the fundamental Kelvin thermodynamic scale of temperature based on the Carnot cycle may be conveniently correlated with the expansion characteristics of a perfect monatomic gas up to roughly 1500°C., but that in the higher temperature range radiation laws such as the Stefan-Boltzmann fourth-power law furnish our most reliable basis for estimating temperature. All other methods such as thermocouples and expansion or deformation devices are secondary standards. A paper on Pyrometry of Liquid Steel in the Open-Hearth Furnace by L. O. Sordahl of the United States Steel Corporation discussed several methods for measuring temperatures of liquid steel and described the use of the Collins-Oseland tube in conjunction with a photoelectric cell and automatic recording equipment. Human Body Temperatures in Health and Disease were discussed by E. F. DuBois, Director of the Russell Sage Institute of Pathology, and his remarks are of particular interest to all who have to work close to glass melting furnaces. Dr. DuBois stated that the zone of normal body temperature is fairly wide, rising in severe muscular exercise to as high as 102-104°F. The body uses shivering and sweating as mechanisms to avoid excessive cooling or overheating. The whole mechanism of temperature control is complex, involving changes in the rate of blood circulation as well as other adjustments.

These three papers give more or less a key to the character of the whole symposium, or at least to that part of it which should interest the glass man. A total of twenty papers were devoted to biology, skin temperature and heat regulation in man, not to mention an after-dinner address by Viljalmur Stefansson, Arctic Explorer, on How Primitive People Adjust to Low Temperatures. Many of these biological papers will be of interest to engineers concerned with problems of air conditioning and its relation to the increase of human efficiency. We are concerned here, however, more with the precise and accurate measurement of high temperatures than with the biological effects.

A group of papers were given on platinum thermocouples and it was pointed out that volatilization and oxidation of the rhodium element may be serious. The chief danger to these thermocouples lies in their use in a reducing atmosphere, and in particular free silicon, even in very small amounts, is a serious contaminant. Thermocouple protection tubes which are darkened by reduction of the silica to silicon should be discarded. The electromotive force generated by the thermocouple should always be measured by a potentiometer, never by a millivoltmeter, if reliable and reproducible results are desired. An important article has been published by Roeser and Wensel entitled "Methods of Testing Thermocouples and Thermocouple Materials": Nat. Bur. Standards J. Research *14* 247 (1935) RP768. As regards base metal thermocouples, A. I. Dahl of the National Bureau of Standards has studied the effect of heating iron-constantan and chromel P-Alumel couples for 1000 hours at temperatures up to 2200°F. under oxidizing conditions. An interesting method on the use of very thin fused silica tubes as protection sheaths for noble metal couples to be immersed quickly in molten steel at temperatures up to 1700°C. was described in a paper by two British investigators, F. H. Schofield and A. Brace of the National Physical Laboratory. The details of their method may be found in the Eighth Heterogeneity Report of the British Iron and Steel Institute, May, 1939. Observations may be taken in 4 to 15 seconds after immersion. The small size and low cost of the silica tube, 25 cents, permit its discard whenever it becomes contaminated. The method might be used for exploring the temperature distribution at different levels in a glass tank and thereby eliminating one source of cordiness. Possibly the new type of preshrunk borosilicate glass recently introduced by Corning would be a useful substitute for fused silica in pyrometer protection tubes.

In regard to measurement of hot gas temperatures, a

paper by H. F. Mullikin and one by H. F. Mullikin and W. J. Osborn of the Babcock and Wilcox Company are of interest. The "high velocity thermocouple" which they describe is protected by a radiation shield and then a stream of hot gases is aspirated past the thermocouple junction at high velocity. This procedure permits better heat transfer and at the same time reduces the radiation losses from the thermocouple to cold walls or other cooler surfaces. The effect of various types of shielding has been investigated. The technique of measuring flame temperatures by wires and thermocouples was described by B. Lewis of the United States Bureau of Mines, Pittsburgh, and G. von Elbe of the Carnegie Institute of Technology, Pittsburgh. Details of theory and practice on problems of this kind may be found in Dr. Lewis' recent book, Combustion, Flames and Explosions of Gases, MacMillan Co., New York, 1938.

Optical pyrometers came in for a session under the leadership of Dr. W. E. Forsythe of the Nela Laboratories of the General Electric Company. Dr. Forsythe himself described several types of optical pyrometers and stated his reasons for preferring the disappearing filament type. He also discussed the use of filters for selecting a narrow band of approximately monochromatic radiation and the choice of the most suitable wave length. A new type of optical pyrometer has recently been placed on the market, which embodies the potentiometer principle in that the voltage drop across the filament is measured rather than the filament current. This will lead to a greater precision in measurement.

Suggestions for fixed reference points for optical pyrometer calibrations were made by Lucks and Russell of the Battelle Memorial Institute and by MacPherson of the National Carbon Company. The Battelle workers recommend the use of a 15 watt pink fluorescent mercury vapor lamp which on a standard 110-120 volt circuit has an apparent brightness temperature of about 2000°F., which appears to remain constant within 15°F. for line voltage changes not exceeding 5 volts. MacPherson states that the positive crater of a pure carbon arc, subliming carbon at atmospheric pressure, maintains a temperature of about 3810°K.

The subject of emissivity came in for a good deal of discussion at the Iron and Steel session which was led by Dr. R. B. Sosman of the U. S. Steel Corporation. Although there are several different kinds of emissivities, namely spectral, total, luminous and color, it may be stated simply that emissivity is a term which expresses the ratio of radiant energy emitted from a given body to that of a similar shaped black body of the same size, at the same temperature. The emissivity must be known in order to provide a correction term to the temperature as measured by the optical pyrometer in order to get the true temperature. Large variations in emissivity occur with different materials. Thus for pure iron at steel melting temperatures the value is about 0.4 while for pure FeO it rises to about 0.7. Glasses in general show high values, and these values vary to some degree with the color and composition of the glass. Certain data along this line were presented by A. G. Worthing of the University of Pittsburgh. There is need for more work in this field in order to have a better knowledge and control of temperatures in glass melting. In order to get around this difficulty of not knowing the emissivity Russell and Lucks of the Battelle Institute and Turnbull of the Canadian National Research Council have developed a two-color optical pyrometer which they claim to be useful above 1000°C. and reliable within 10°C. The principal of the instrument is that the radiation is split into a red and a green beam, and the ratio of the intensities of these two beams is dependent only on the temperature of the source, and independent of its emissivity or of the transmission of the intervening space, even though it may be variable.

One paper not on the announced program but containing a great deal of practical information of interest to the glass melter was given by Larsen of the U. S. Steel Corporation. The subject matter dealt with methods of furnace temperature control as used in the Corporation, and is essentially that presented by Sosman under the title "Pyrometry and the Steel-Makers Refractories," Journal American Ceramics Society *17* 37-49, February, 1938. This paper offers a practical solution to the difficult problem of maintaining and recording high temperatures under the conditions of operation of a large melting furnace.

The session on Education, as pertaining to the problems of temperature, deserves particular mention. P. H. Dike of the Leeds and Northrup Company described the nine months course which is given to engineering graduates who have been accepted for sales work with this company. J. M. Cork of the University of Michigan, the author of a well known text on Pyrometry, emphasized the importance of laboratory work and problems and discussions in addition to formal lectures on the subject. Howe and Boelter of the University of California have designed a list of experiments whose purpose is to bring out the difficulties and sources of error inherent in the more common types of temperature measuring instruments, especially where time lag phenomena may occur. R. B. Sosman stated that the industrial plant needs two types of men to keep its temperature under control; one, the practical resourceful tinkering type who has had little formal schooling but a lot of mechanical experience, will keep the machines in order. The other, the research type, should be always inquisitive and "skeptical of the misinformation supplied by industrial instruments as usually installed and maintained." This man should be well founded in chemistry and physics and mathematics. He should understand the basic theory of temperature itself and of the instruments designed to measure it. The proper function of a college in this modern world may be expressed in a statement which is attributed to President Compton of M. I. T., "a college is not an intellectual stock-farm where animals are fed and fattened for the market, but a place where opportunity is given to the students to learn in a stimulating environment."

Factors Affecting the Life of Platinum Thermocouples. *By C. F. Homewood, New Jersey Zinc Company.*

Platinum-platinrhodium Thermocouples when used in service undergo changes due to contamination from foreign substances entering the primary protecting tube. Additional changes result from deteriorating influences within the

*Some years ago the writer became interested in the question of how much chemical reaction can take place in a system whose temperature is steadily changing. The calculations, for various time-temperature relations, have been published by J. Sherman in a paper entitled Reaction Rates in Non-Isothermal Systems, Ind. Eng. Chem. *28* 1026-1031 September 1936. They may be of interest to some readers of Glass Industry.

tube itself. The author discussed some of these latter changes, including contaminations, volatilization and oxidation of the rhodium element, and distortion of the wires affecting grain boundaries. Several commercial tests were made in which these factors were studied and means of minimizing them were tried. The results obtained were interpreted by the means of homogeneity determinations and by photomicrographs on the element wires. Typical examples were shown.

Gas Temperature Measurement and the High Velocity Thermocouple. *By H. F. Mullikin, The Babcock and Wilcox Co.*

While the temperature of a solid or a liquid can be measured quite accurately with an ordinary thermocouple, difficulties arise when one attempts to measure the temperature of a gas with such a thermocouple. These difficulties arise from the fact that in the case of liquids or solids one is dealing with materials that are good conductors and which readily allow the thermocouple to reach their temperature. In the case of gases a different set of conditions exists. A thermocouple immersed in a gas receives heat by conduction from the gas, but due to the fact that all gases are permeable to radiant heat to some degree, the thermocouple will radiate or absorb heat from the walls of the chamber containing the gas. If the walls are hotter than the gas, the thermocouple will absorb heat from the walls and will give readings higher than the true gas temperature. On the other hand, if the walls are colder than the gas the thermocouple will radiate heat to the walls and will give temperatures that are lower than the true gas temperature. (Note: Both of these situations are met in the glass industry, the first when the air for combustion passes up the regenerators and the second when the waste gases pass down the regenerators.—Ed.)

This process of heat exchange, when considered mathematically, was shown to be a function of the fourth power of the absolute temperature. The radiant heat transfer will therefore be very great at higher temperatures where the wall temperature is at all different from the gas temperature. For example, a thermocouple located in a gas at 2,500° F. located among walls at 2,200° F. will have a much greater relative error than a thermocouple located in a gas at 700° F. located in a flue at 500° F .

Twenty-six different methods for eliminating this error in gas temperature measurements were described. The most recent developments as well as many of the older methods were covered in this discussion.

Of the many methods listed, only the high velocity type thermocouple method appeared suitable for investigating the present problem; i.e. the measurement of the temperatures of slag-bearing gases up to 3,100° F.

With the high velocity thermocouple, the gas is caused to flow over the hot junction of the couple by the means of an aspirator or pump of some sort. In this manner the heat transfer to the couple is increased causing it to read more correctly. In addition the tip of the couple is shielded, thus lowering radiation errors. As the ordinary high velocity thermocouple becomes plugged with slag when the temperature of slag-bearing gases is measured, the author has developed a new form of high velocity thermocouple for such work.

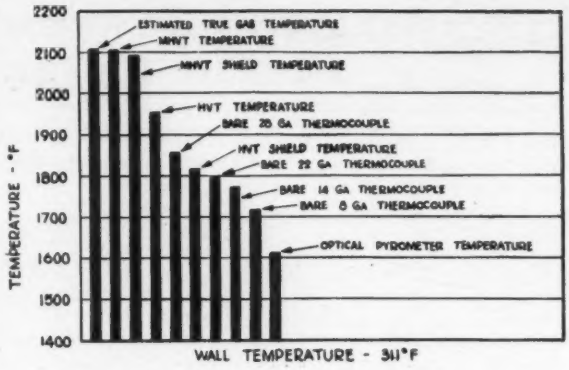


Fig. 2.

The general arrangement is shown in Fig. I. The construction is such as to facilitate repair when the instrument becomes plugged up or damaged by slag.

The gases are drawn through a water cooled tube by means of an aspirator operated by compressed air. At the furnace end, a thermocouple hot junction surrounded by a porcelain radiation shield is heated by the high velocity gases flowing past, thus giving the gas temperature.

In operation, as the gas velocity is gradually increased the temperature indication given by the thermo element will also increase. The amount of increase gradually becomes less until at some value of gas velocity, further increase does not result in an increased temperature indication. To prevent undue clogging, the suction should be "on" only during the time the readings are being taken.

Accuracy Tests of the High Velocity Thermocouple. *By H. F. Mullikin and W. J. Osborn, The Babcock & Wilcox Co.*

In this investigation it was desired to obtain a measure of the absolute accuracy of the high velocity thermocouple. Apparatus was constructed and so arranged that the true gas temperature in a 4 inch square test section could be obtained by the means of specially constructed temperature measuring sections before and after this test section. With this apparatus the readings of a single shield high velocity thermocouple, a multiple-shield high velocity thermocouple and various sizes or ordinary bare thermocouples were taken under a variety of test conditions.

The data obtained showed that the multiple shield high velocity thermocouple gives essentially true gas temperature readings, that the high-velocity thermocouple reads a lower temperature, while the bare thermocouples read a still lower temperature depending upon the wire diameter. Typical data illustrating these results are given in Table I (page 442) and are shown graphically in Fig 2, above.

From the results of this investigation it was recommended that where wall temperatures differ appreciably from gas temperatures, a high velocity thermocouple be used for the accurate measurement of the gas temperature. In cases where the gas contains slagging materials and the practical use of a shielded high velocity thermocouple is prohibited,

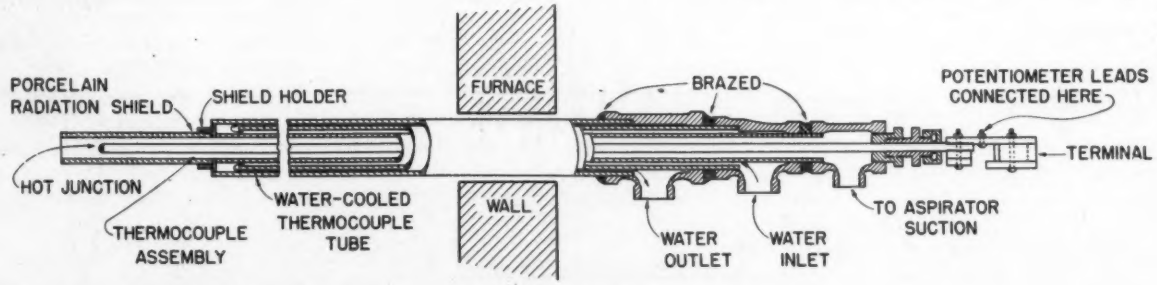


Fig. 1. Water-cooled high-velocity thermocouple for rugged service.

the high velocity type should be used. The necessary correction may be established by special tests.

TABLE I

Type of Measurement	*Temperature °F*
Estimated true gas temperature	2105
Multiple shield high velocity couple	2103
MHVT Shield Temperature	2090
High Velocity Couple	1963
Bare 28 gage thermocouple	1855
H. V. T. Shield Temperature	1817
Bare 22 gage thermocouple	1801
" 14 " "	1772
" 8 " "	1713
Optical pyrometer (hot-wire) temperature	1607
Wall temperature	311

The Relation of Uniform Pyrometer Records to Uniform Products. *By J. A. Doyle, W. S. Rockwell Company.*

The relation of uniform pyrometer records to uniform products is not generally sensed in actual practice. Evidence of uniformity in the temperature record is frequently offset by proof of irregularity in the product itself. Pyrometry practice in industry is not up to the high standards of design and production maintained by the instrument manufacturers. For example: Variation in color of ceramic products, or in the grain size and physical properties of metallurgical products, even though produced with equipment provided with automatic temperature control, suggests the need and possibility for better pyrometric practice in the several industries to determine the causes of irregularity and the possibility of improvement.

Physical factors affecting uniformity of the product, in heating and cooling, are just as important as factors related to indication and control of temperature. (Editor's Note: This is particularly true in the glass industry. Often, more attention is paid to the maintenance of a straight line on the recorder than to the temperature distribution in the furnace. The temperature distribution in the furnace affects materially the homogeneity of the glass delivered to the machines.)

A "Quick-Immersion" Technique for High Temperature Measurement on Fluids. *By F. H. Schofield and A. Grace, National Physical Laboratory.*

A description was given of a so-called "quick immersion" technique by which a platinum thermocouple is applied to the routine measurement, up to a maximum of 1700° C., of the temperature of liquid steel in the furnace and elsewhere. The method consists essentially in lightly sheathing a couple in silica so that it can be plunged into liquid steel, give a reading in a few seconds, and be withdrawn intact. The mounting of the couple is shown in Fig. 3.

The device while designed primarily for liquid steel can be adapted with slight modifications for other liquids. In the case of glass, however, the low thermal conductivity of glass as compared to metallic liquids such as steel, may cause too great a lag if the "quick immersion" technique is desired. It was indicated that the attack on platinum by glass is so slow that the use of bare couples might be advantageous.

A description of a "quick immersion" technique for optical pyrometers was also given. The details of the set up are shown in Fig. IV.

An alternative method using a photoelectric cell was also described. This apparatus is shown in Fig. V.

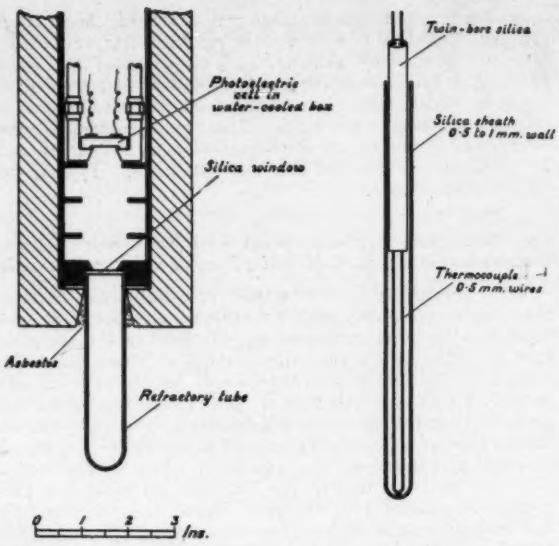


Fig. 3 (right). Mounting of thermocouple, and (left) Fig. 5. Apparatus arranged for use with photoelectric cell.

Optical Pyrometers. *By W. E. Forsythe, General Electric Co.*

An optical pyrometer is a device for measuring the temperature of bodies from the intensity of their radiation within the visible spectrum. This, of course, presupposes blackbody conditions. This type of pyrometer is of special advantage for the measurement of the temperature of bodies that are so small or so situated as to make it difficult to measure by other means. This instrument is also useful for measuring very high temperatures since it need not be affected by the temperature of the source being measured, and the calibration can be quite accurately extended to very high values.

The several types of optical pyrometers were described by the author and some of the reasons given for the preference of the disappearing filament type. Some of the reasons for using a so-called monochromatic beam of light in making the measurements were also given, the best region of the spectrum to use, and some of the different methods used for obtaining the monochromatic radiation were shown.

The definition of the effective wavelength of the screen, the necessity and the method of its use was outlined. The standard and secondary methods of calibrating optical pyrometers and methods of extending the temperature scale above that of the pyrometer lamp were discussed.

Accuracy tests were reported and discussed together with the corrections and the various precautions that are necessary for this kind of work such as alignment of the instrument, the relative angular size of the two cones of light, the pyrometer filament and lamp and its ambient temperature, the measurement of the current through the pyrometer filament and the care of the pyrometer as a combination optical, mechanical and electric instrument.

Several different commercial forms of this type of pyrometer were described and some of the advantages claimed for each were given and discussed. (*Continued on page* 467)

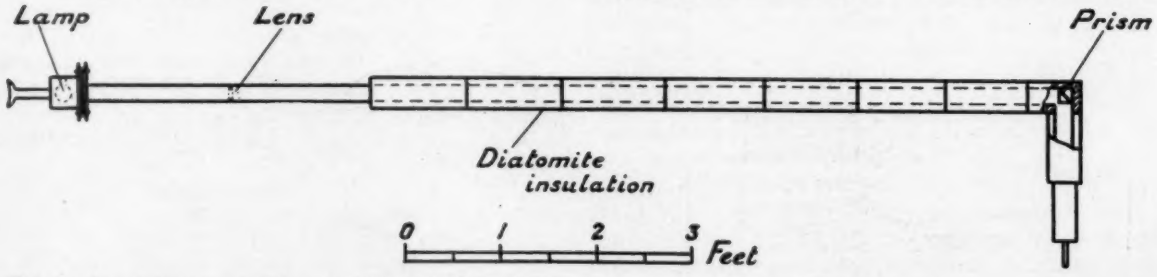
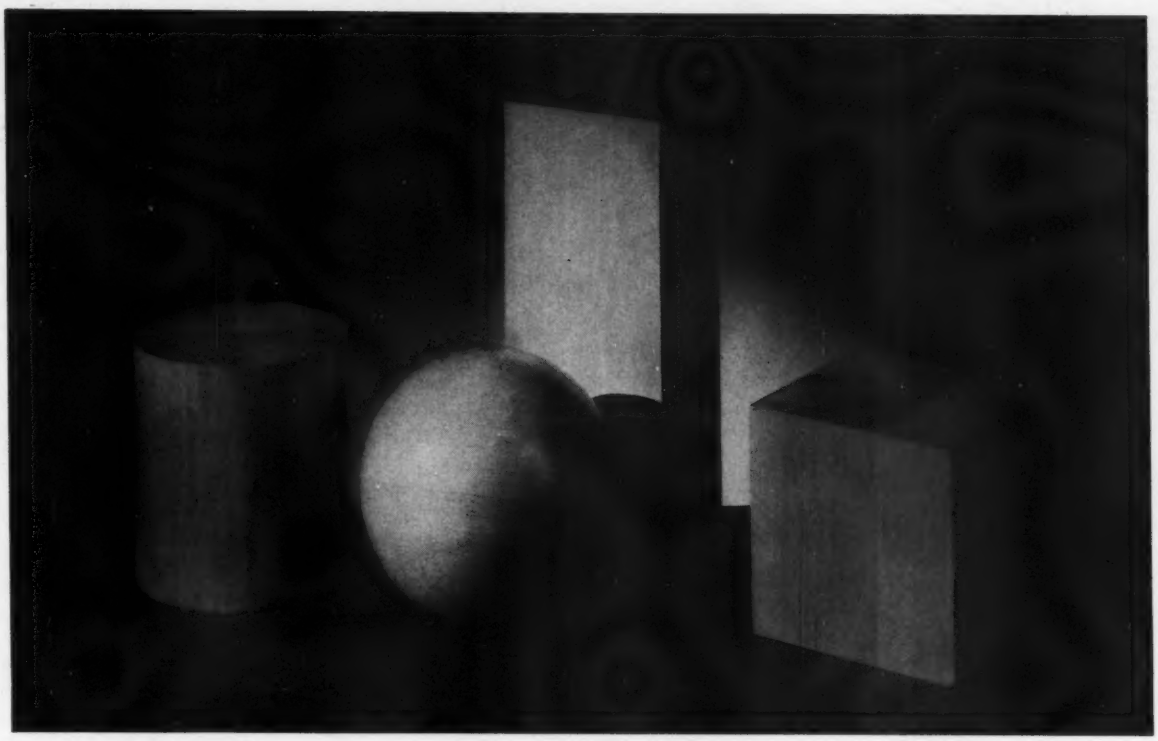


Fig. 4. Apparatus arranged for use with optical pyrometer.

IMPROVING THE STRENGTH OF GLASS CONTAINERS THROUGH DESIGN

By LEONARD G. GHERING

PRESTON LABORATORIES, Butler, Pa.



CYLINDER	SPHERE	PRISM	CUBE
1/8″ wall	1/8″ wall	3/16″ wall	3/16″ wall
95 sq. in. surface	82 sq. in. surface	131 sq. in. surface	112 sq. in. surface
11.3 cu. in. glass	9.8 cu. in. glass	22.5 cu. in. glass	19.2 cu. in glass
16 oz. glass	14 oz. glass	32 oz. glass	27 oz. glass

Photograph 1: All models are based on a capacity, inside walls, of 60 cu. in. The dimensions of the Prism are arbitrary. Wall thicknesses are comparative to give approximately the same strength. The photograph illustrates the fact that redesign of the container to give lower ratios of surface-to-volume allows lighter weight without sacrificing strength.

It is hardly an exaggeration to say that the variety of modern designs, sizes and shapes of glass bottles and jars is exceeded only by the variety of the fragments in a pile of cullet. And, although the artistic designer and the adaptation of glass to private molds, "distinctive packages," and "attractive packages," account for much of the variety and most of the frills and decoration in modern design, many other factors are very important. Some customers ask for all sorts of emblems and complicated lettering molded into their bottles, and usually insist on their own ideas as to where these adornments should be located, and specify certain types of labels.

Bottle design must be adapted to a great variety of mechanical handling devices—washing machines, washing machine pockets, brush spindles, inside brushes, fillers, filling tubes, cappers, pasteurizers, labelers, conveyors and cartoners, most of these units existing in many makes and models often differing widely.

A variety of types of closures is in existence. Head space and filling point have to be considered. Sometimes compact shapes are necessary for efficiency of packing or storage space.

Another factor of great importance recenty has been that the weight of the containers must be a minimum in order to reduce their initial cost as well as freight and handling charges.

Although modern forming machines are sufficiently flexible to meet most of these demands, there are numerous angular shapes, sharp edges, and cut glass design imitations that are impractical or impossible to fabricate; the attainment of uniform distributions of the glass is sometimes a very critical matter. Consequently, in order to obtain high quality and efficient machine production, the packing department, the mold shop, and the fabrication foreman necessarily impose many more restrictions on design. Compromises have to be effected between what is wanted and what can be made.

Because of these demands, difficulties, and restrictions with respect to design, it is small wonder that the designing of bottles for maximum mechanical strength is as yet

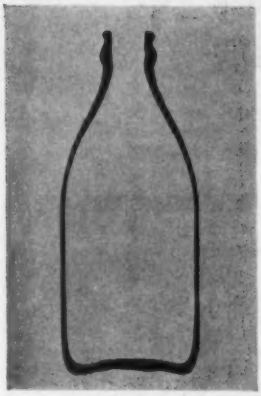


Fig. 1. No Deposit Beer showing bulged shoulder and rounded sidewall base junction. This design, even on light weights, tends to give good internal pressure, thermal shock, and impact strength.

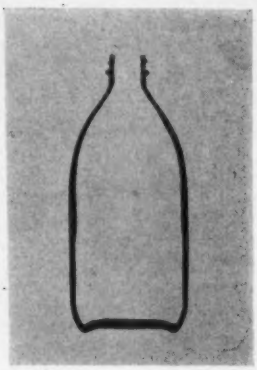


Fig. 2. This design on a pint juice bottle gives good strength with a minimum of glass.

an undeveloped technique in the industry. Day by day, however, this situation is rapidly changing, mainly for two reasons:

1. Several laboratories and engineering departments connected with the industry are making careful comparative strength tests and accumulating data on all types of bottles. In some instances systematic programs have been instituted. The recent development of more accurate testing equipment has been helpful in this respect. Also the application of the comparatively new technique of locating the origins of fractures has enabled testing departments to identify the weak spots in a container.

2. The demands for lighter weight containers in the industry has focussed everyone's attention on the possibility of getting equivalent or even greater mechanical strength with less glass through improvement in the design and in the distribution of the glass in the container.

The purpose of this article is to discuss some of the definitely established general principles with respect to design and its relation to strength from the theoretical as well as from the practical point of view.

Theoretical Aspects of Design for Economy of Material

Any carpenter ought to be familiar with the fact that it takes more lumber to build a long rectangular box than to build a cubical box to hold a given volume. The same idea applies to glass containers; the surface area and the weight of glass required to enclose a given volume with, say, $\frac{3}{16}$" wall thickness depends on the form or shape of the container. The exact relationship between form and weight is given by the surface-to-volume ratios of the various simple geometric shapes. In a recent article Dr. J. H. Toulouse* illustrated the relation between form and design with photographs of four wooden models. These are reproduced in Photograph 1. The legend with the photograph gives the surface area required for a sphere, cylinder, prism and cube respectively, to enclose a volume of 60 cu. in. (about 1 quart). Also the weight of glass required for these various shapes is given.

From the data with the photograph it is seen that the container form most economical of container material is a perfect sphere, the surface required to enclose a given volume being a minimum. Of the four illustrated forms the next most economical of material is the short cylinder. In practice this is approximated in a round half-pint mason jar. The cube and prism are still less economical in the order named.

Economy of Glass in Practice

In practice the ideal spherical shape cannot be used for a container. Although it is approached in many designs, in general it is not well adapted to machine handling and other practical requirements.

On the other hand, short cylinders, fortunately, are well adapted to most practical requirements for containers. Theoretically, the cylinder most economical of material is one whose weight approximately equals its diameter. However, since a bottle has a shoulder, finish, and relatively thick base, its height should be somewhat greater than its diameter. Also, in practice the height and shape of the shoulder and neck are an important consideration. Although the amount of glass required for the finish is usually constant, this is not true for the neck and shoulder. The amount required for the latter depends on the shape and contour. By way of illustration, the amount of glass in the shoulder, neck and finish of a 10-oz. weight, 12-oz. capacity beer steinie is ½ oz. greater than that in the 12-oz. stubbie. Along the same lines of reasoning, it is obvious that the 12-oz. capacity ginger ale type bottle has too long a neck and is otherwise too tall to take full advantage of the theoretical possibilities of economy of glass in the neck and shoulder.

Also, by modifying the lower part of cylindrical bottles economies of material can be gained in practice. If the lower sidewall and base sidewall junction is rounded off, the ideal spherical curvature is being approached for at least that part of the container. Fig. 1 is an example of economical curvatures both in the shoulder and near the base. Fig. 2 and 3 show greater modifications in the lower part.

Likewise glass can be saved in the rectangular shapes if the factory designer is permitted to round off the edges of the sidewall. Even greater savings can be made in the shoulder and basal regions. The great difference between the glass required for an unmodified rectangle as compared with a sphere is illustrated by Toulouse's calculations (legend, Photograph 1). Although the savings accomplished by rounding off the edges are rather meagre compared with those occurring from the use of a different shape, they are none the less worthwhile.

The Theoretical Effect of Shape on Strength

The container shapes which are the most economical of material are the strongest containers in one sense: they give the maximum wall thickness for a given weight of glass. Theoretically, however, the stress developed in a container by an imposed force depends not only on the

*"The Glass Industry Charts a New Course in Design," *The Glass Packer*, April, 1939.

wall thickness but also on the dimensions and form of the container.

The amount of stress developed by a given internal pressure in containers of equal wall thickness and contents, but of different forms and shapes, is of particular interest. This stress will be a minimum in the sphere. It will be somewhat higher in an ellipsoid or other curved surface characterized by "double curvature"; the less the radii of curvature, the greater the strength (for equal wall thicknesses and volumes). In a short cylinder the stresses will be still higher, partly because of lower strength of the "single curvature" in the sidewall and partly because of the flat "drum-skins" at the ends. The latter cause particularly high localized bending stresses at the junction of the end and sidewall. It is because of the inherent weakness of flat ends, and the localized stress at the right-angle edge, that cylindrical metal high pressure containers such as steam boilers normally have dome-shaped ends (double curvature). However, we cannot put a dome end (base) in a bottle because the flat surface is necessary to allow the bottle to stand upright.

Because of all these stress relationships, the best choice of height-diameter ratio for maximum strength of a cylinder is not the same as that for minimum surface-to-volume ratio, but requires a somewhat taller bottle.

The stress developed in cubes and prisms is still higher than that for cylindrically shaped bottles (assuming equal internal pressures, wall thicknesses, and volumes). The cube is better than the rectangle since the area of its longest and widest panel is a minimum. Bottles having wide, flat panels are hopeless for pressure containers.

The mechanical stresses produced by thermal shock are different from those just described for internal pressure. For a given wall thickness, the thermal shock stresses in a sphere are a minimum because of the absence of corners and edges.

In cylindrical bottles, the greatest stresses develop at the junction of the base and sidewall due to the fact that the peripheral stresses in the lower part of the sidewall combine with the radial stress of the base at this junction. In rectangular shapes the thermal shock stresses are greater than for the other shapes; the stresses reach their maximum at the end-sidewall junctions because of the combined effects at the corners and edges.

With respect to the stresses produced by mechanical impact, thick-walled convex low-radius "double curvature" surfaces would be ideal. This is illustrated by the young lad who is unable to break an eggshell when squeezing it hard between his knees and distributing the force uniformly on the two ends by the use of the palms of his hands.

Practical Aspects of Strength and Design

The rudiments of the above theoretical principles have been recognized by the industry. This is shown by the predominance of cylindrical bottles over square and rectangular ones for pressure containers. Also the industry has shown a preference for broad and rounded shoulders, edges and corners.

Practically speaking, there is a lot more involved in the designing of containers for strength than the mere theoretical considerations and principles. Glass as a material conforms with the strength of materials' principles, as outlined in textbooks, up to its elastic limit. If this limit is not exceeded, glass is a very strong structural material. However, when the elastic limit is reached, glass differs from most other materials in that there is no plastic flow; glass is brittle rather than plastic, and fractures once started are readily propagated.

Glass in the form of a container has further unique properties: it is fabricated in a mold by a specialized process; the surfaces are as unique as they are important in the strength of the article; there are several types of fabrication defects which have practical importance; and even in the best present practice the distribution of the glass, i. e., uniformity of wall thickness, is seldom ideal. Further, the container itself is unique in its details of shape and form; it must have a finish, a neck, a base, a shoulder, molded adornments, etc.

Internal Pressure Strength in Practice

For pressure containers, in practice, we are most interested in cylindrical shapes, and modifications thereof. In order to attain the strongest possible container, we are interested in the effect of height to diameter ratio on strength and the effect of length of neck and shoulder contour on strength. We are particularly interested in the effect of various curvatures in the junction of the base and sidewall and other basal modifications on strength. Theory does not give the complete answer to these questions. Rather, it is necessary to fall back on experimental bottles and empirical testing for several reasons:

1. The finish, neck and shoulder curvatures are too complicated to lend themselves to theoretical stress calculations.

2. The curvatures, both inside and outside, of the base and lower part of the sidewall of the cylindrical bottles are also complex, and theoretical calculations are further complicated by the rather large variations

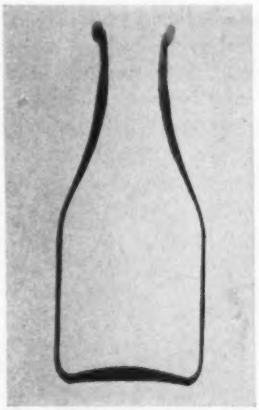


Fig. 3. The well rounded lower sidewall on this quart milk bottle tends to give good thermal shock and impact strength.

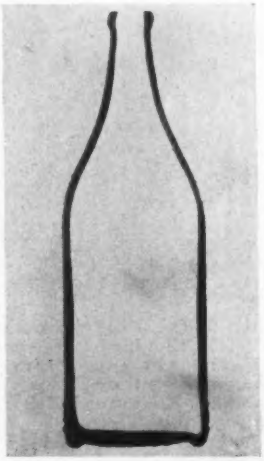


Fig. 4. In this quart beverage bottle the rings and lettering in the Murgatroyd Belt region are particularly bad. A bump check can easily be driven through the thin spot in the lower sidewall on the thin side.

in thickness of the glass usually produced by most fabricating machines in this region (heel taps, etc.).

3. The same variations in thickness and inside curvature in the base and lower part of the bottle make it virtually impossible to calculate accurately the ideal height to diameter ratio for a given volume.

Furthermore, fabrication irregularities and defects and the condition of the surface of the glass make a two or three-fold difference in the strength of the container. One type of defect is an "invisible check" in the glass at the contact point in the base (portion of the base which touches any flat surface upon which the bottle is sitting). Such an invisible check may cut the pressure strength by half or more, and is capable of detection only by an internal pressure test on the bottle or by etching with hydrofluoric acid, or other specialized laboratory techniques. Whether or not such a defect is formed may depend on the design or thickness of the basal portion of the bottle, and seems to be unpredictable in the present stage of the strength designer's experience. The remedy for such checks lies essentially in proper temperature control of the glass and the conveyor belt and is more of a practical problem than a theoretical one of design. However, design may enter into the final solution.

Another type of defect is a "cold fillet" of glass along the blank mold seam which does not flow freely or "blow out" in the finish mold, and therefore produces a "baffle mark." These baffle marks may or may not affect the strength, and the exact effect can be determined only by testing the bottle. Also the position of this baffle mark in the base may be a determining factor in the strength of the bottle. The correction of baffle marks is essentially the job of the mold shop and the machine operator rather than the designer.

The effect of slight "heel taps" and other variations in the basal thickness on the pressure strength depends to a great extent on all the details of the finish mold design and the thickness. In one design a heel tap may be particularly serious, whereas in another it may not. The strength of the base is most critical when the base is large or the height-to-diameter ratio small. In determining the maximum width of a bottle to hold a given volume, it is therefore again necessary to supplement all theoretical considerations of surface to volume economy with empirical data on the pressure strength.

The condition of the surface of the glass may double or halve the pressure strength of a container. Plant inspectors usually roll two or more together in their inspection. Both the position and seriousness of the damage, as well as the resulting loss of strength, depends on the weight, size and design of the bottle. Increasing strength thus becomes a matter of preventing damage. Sometimes changing the design will help to prevent the damage (Figs. 4 and 6).

Also of great importance on the pressure strength of bottles is the uniformity of thickness or the excellence of the distribution of the glass attainable in the fabrication of a particular design. Obviously, unless the particular design of bottle can be made well, it is worthless in spite of any theoretical good points.

For maximum pressure strength in practice the ideal distribution seems to be a slightly greater thickness of sidewall in the lower part (Fig. 1). The No-Deposit Beer design shown in this figure is excellent in economy of glass, distribution of glass, and strength. Also, this bottle has good stress distribution and illustrates the "double curvature" bulging shoulder, short neck, and rounded sidewall base junction. Fig. 2 shows a similar design on a non-pressure container.

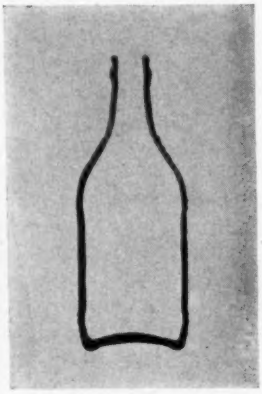


Fig. 6. This is an improved design of a carbonated beverage Steinie. Note that the lower sidewall is rounded off and the rings are moved up to the top of the Murgatroyd Belt where they do considerably less damage than lower down as in Figure 4. This design has good thermal shock strength.

In order to attain better stress distribution on prism-shaped and panelled bottles the same ideas may be applied. Although drastic changes from panels to single curvature or double curvature may not be possible, it may still be possible to salvage a few modest improvements by rounding off edges and corners and shortening straight panels.

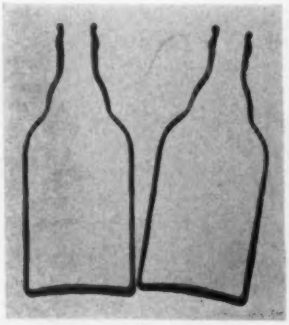


Fig. 5. (a) Two square base Steinies showing how the base of one can easily drive a bump check through the vulnerable Murgatroyd Belt region of the other.

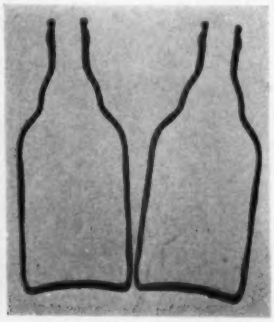


Fig. 5 (b) Similar Steinies with rounded bases showing how the convex surfaces in this region cannot inflict localized blows and therefore do not produce bump checks or other damage.

Practical Design for High Thermal Shock Strength

To a great extent practical experience in thermal shock strength follows theory. Thick walls and junctions break more easily than thin ones; large diameter bases weaken the container; and acute angles and small radii curvatures at junctions give higher localized stresses than well-rounded edges.

Figs. 1, 2, 3 and 6 illustrate designs having good thermal shock strength.

Just as was the case in internal pressure strength, commercial bottles often develop unexpected weaknesses in thermal shock, and for much the same reasons. Bad

baffle marks have long been recognized as a source of difficulty, but the machine operators' problem may sometimes be simplified by modifications in design.

Checks will also ruin the thermal shock strength, a check orientated peripherally in the base-sidewall junction being the most serious. This differs from pressure strength checks in that the latter are most serious if they have a radial direction.

Of perhaps even greater practical importance in the thermal shock strength is the condition of the surface. Damage in the lowest ½ in. to 1 in. of the sidewall was found by Murgatroyd to be particularly serious. Scratches and bruises on the outside in this region do more damage than in any other part of the bottle. The region is sometimes referred to as the "Murgatroyd Belt." For a bottle having a square sidewall-base junction, deep bruises, and even "bump checks" can be easily driven into the glass by the inspector, especially if he inspects the bottle while still hot. Further damage

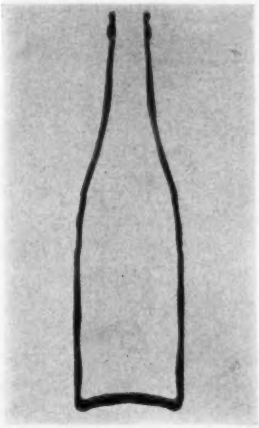


Fig. 7. A square base beverage bottle with a slight heel tap in the lower sidewall adjacent to the rigidly supporting base. An impact at this thin spot in the lower sidewall easily produces breakage.

is caused in bulk pack shipping cartons and in all subsequent handling in service. Rings and lettering or other adornments in the Murgatroyd Belt region are particularly bad (Fig. 4).

Much of the damage in the Murgatroyd Belt can be avoided by changing the design of the bottle. Undercut the lower part of the sidewall (or round off the base-sidewall junction) so that when two bottles are bumped side by side they do not inflict damage in this important region (Fig. 5). The prevention of the damage increases both the pressure and thermal shock strength, the thermal shock strength being particularly sensitive to the presence or absence of damage in this region.

Furthermore, rounding off the base usually gives a thinner sidewall-base junction, which increases the thermal shock strength. Also, the smaller diameter of the flat portion of the base is favorable (Fig. 6).

Effect of Design on Impact Strength

Theoretically it is difficult to predict just how or where or what shape container will break most easily when subjected to mechanical impact. In general one would expect that low radius double curvature and thick walls would be favorable for great strength. However, our greatest practical interest lies in the essentially cylindrical (single curvature) bottles with or without rounded bases. The strength at the various points along the straight part of the sidewall is therefore important.

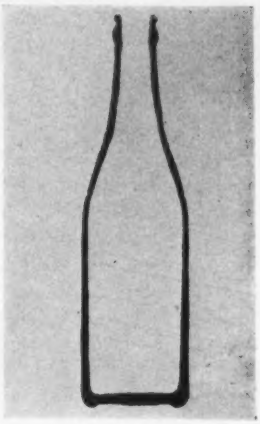


Fig. 8. A square base beverage bottle with relatively thick lower sidewalls which tend to increase the bottle's resistance to external impact.

Various types of impact testing equipment have been used from time to time. In the Butler Laboratory we have been using a newly designed semi automatic ball dropper. In this test, for example, on 12-oz. steinies, 16 steel balls ¾ in. diameter are dropped successively by an automatic magnetic release. The bottle (lying on its side) is rotated by the machine so that the 16 impacts are in the form of a spiral around the barrel of the bottle, starting at the shoulder and extending to the edge of the base. The impact can be varied by changing the height from which the balls are dropped.

In a bottle with a straight rather than an undercut lower sidewall, and with even distribution up and down and round the sidewall, breakage in a typical case will not occur with the first 14 balls; but it will very likely be broken by one of the last two which strike the lower part of the sidewall. This is the part which is rigidly supported by the base. The explanation probably is that in the center of the barrel of the bottle the glass can give when it is impacted, much as a window-pane will give if one pushes it with their finger in the center of the panel. If one strikes either the window or a bottle at a point adjacent to its rigid support, in the lower sidewall next to the base in the case of the bottle, and near the edge in the case of the window pane, it will break easily.

A bottle which has a thin spot in the sidewall adjacent to the base is very weak; the thin spot is more serious there than at any other part of the barrel (Fig. 7).

On the other hand, the barrel of a bottle may be surprisingly thin, providing it is uniform, and still not break in the center of the barrel. Breakage near the rigidly supported base may be decreased if the glass is a bit thicker in the lower sidewall (Fig. 8).

Let us now consider the effect of a rounded base design. It is harder to strike the bottle, either in the test or in service, at this point with other than a glancing blow. Furthermore, the stress distribution on the rounded surface is more favorable. Also the Murgatroyd Belt is not as easily damaged by the inspector. Many types of light weight bottles having this undercut design have shown excellent impact strength in the above test.

The Relation of Distribution and Design to Lighter Weight

Having chosen the proper design and determined the ideal distribution of glass, high strength is assured if

(*Continued on page* 472)

SAFETY PLATE GLASS

By GEORGE B. WATKINS
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Safety glass used today in modern transportation, including the glazing of automobiles, buses and trucks, operating on land highways, may be grouped in two general classes: 1, Laminated Safety Glass; 2, Heat-Strengthened or Tempered Safety Glass.

Laminated safety glass, which is by far the most widely used safety glass in this country, may be defined as a composite structure consisting of two lights of glass and an interposed sheet of plastic or non-brittle material. In general, its manufacture consists in assembling a sheet of preformed plastic between two lights of glass and the resulting glass—plastic layers bonded into a unitary structure by the application of heat and pressure.

A deviation from this general practice is in the formation and application of the plastic interlayer. Instead of using a preformed plastic sheet to sandwich between two lights of glass, a solution or dope of the plastic material is flowed upon one surface each of the two lights of glass, allowed to dry free of residual solvents, then assembled with the plastic surfaces together and bonded by the application of heat and pressure.

The glass itself, either plate or sheet, used in the manufacture of laminated safety glass has the same physical properties with respect to hardness, brittleness and breakability, as ordinary glass. Therefore, the safety features of laminated safety glass depend solely upon the plastic or strengthening layer placed between and bonded to the two lights of glass. The plastic and not the glass is the safety element.

On the other hand, the safety characteristics of Heat-strengthened or Tempered Safety Glass depend upon a change in the physical characteristics of the glass itself, which is brought about by a special heat-treating operation. In general, its manufacture consists in placing the light of glass to be heat-treated into an electrically heated furnace, where its temperature is quickly but uniformly raised to the softening point of the glass. The glass is then removed from the furnace and suddenly but uniformly quenched by blasting its surfaces with cold air. The glass resulting from this operation is highly and uniformly strained, the outside surfaces being in a high state of compression, while the innerlayer is in a state of tension.

Analyzing the quenching operation: When the glass plate comes from the furnace, the blast of cold air suddenly chills the outside surfaces to a temperature below that of the central layer. The resulting stresses are relieved by the mobility of the glass, especially in the central layer. Then, as the light of glass is allowed to cool down to room temperature by normal radiation, the excess temperature of the central layer is removed, so that the central layer tends to contract more than the outer layers and in so doing places the outside layers in a high state of compression.

From the foregoing, it is readily seen that the safety characteristics produced by a given heat-treating process are dependent solely upon the physical properties of the parent glass; namely, its coefficient of expansion and the relatively low heat transfer by conduction.

There is, of course, a balance between the compressional and tensional forces in a light of properly made heat-strengthened glass. This condition may be referred to as an unstable equilibrium, since it can be quite easily unbalanced by breaking or penetrating the compression layer. For this reason, heat-strengthened glass is vulnerable to impact from small, sharp objects capable of chipping or breaking the glass surface. When this condition arises, the entire light of glass breaks up into small, relatively harmless particles, compared to the sharp, dagger-like pieces characteristic of ordinary glass.

The existence of compressional and tensional layers in heat-strengthened glass can be demonstrated by actually splitting the compressional layer from one side of the heat-treated specimen by the following procedure:

A multiple ply glass is first made by bounding ordinary ⅛-inch plate glass to both sides of heat-strengthened

A paper delivered before the Metropolitan Section of the American Society of Mechanical Engineers as part of the 75th Anniversary observance of the Columbia School of Engineering, November 8, 1939.

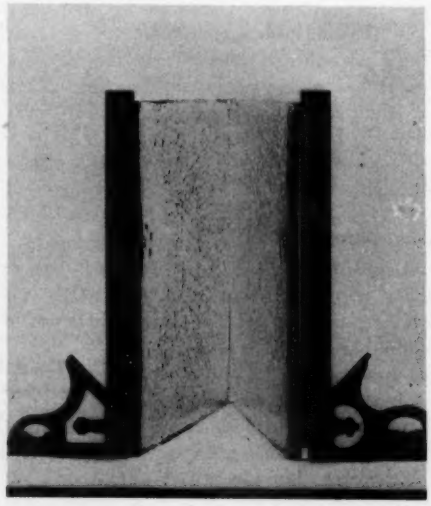


Photo 1 (left) shows the multiple lamination intact. Photo 2 (right), the result of splitting the multiple lamination. The part at the left of Photo 2 has the thin compressional layer bonded to the ⅛″ plate; while the right has the central and a compressional layer bonded to the ⅛″ plate. The concavity of the ⅛″ plates, as illustrated by the straight edges, is evidence that the thin film was in compression before cleavage of the heat-strengthened glass.

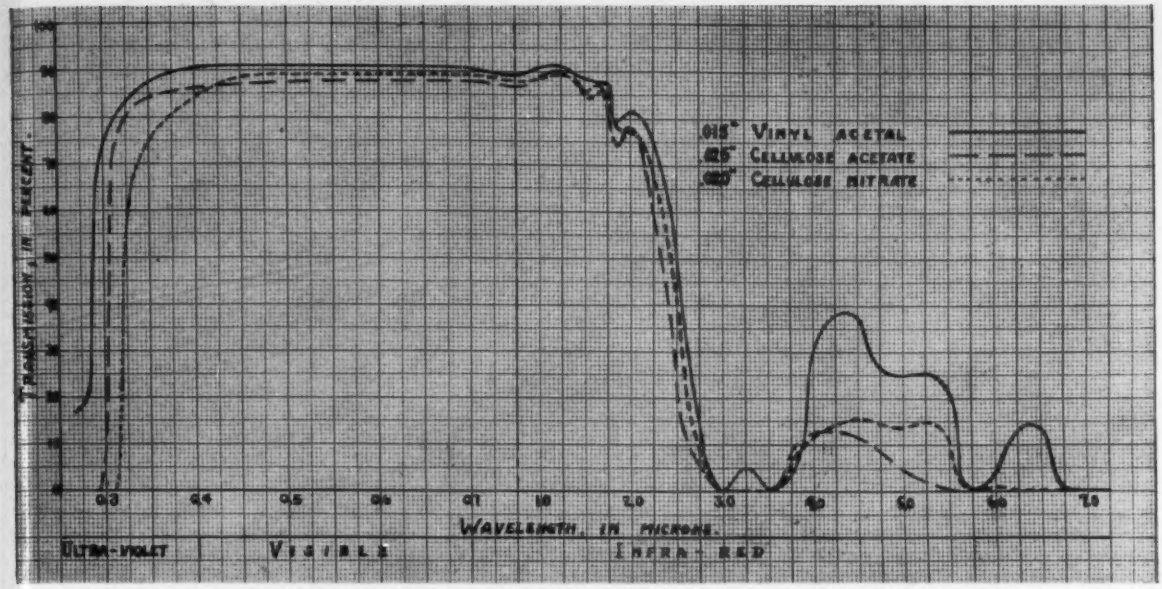


Fig. 1. Showing the spectral transmission characteristics of the three plastics in the same thicknesses used commercially in sheet form for safety glass manufacture during the past 10 years.

glass by the customary laminating procedure. Then, the light of heat-strengthened glass is fractured by impact with a sharp instrument at the exposed edge. As a result, one of the compressional surfaces will split or cleave free from the remaining portion of the heat-strengthened glass in the manner illustrated. See Photos 1 and 2.

A number of measurements made on the compression layers, split or cleaved in the manner described, show that the compressional film on ¼-inch heat-strengthened glass varies in thickness from 0.007 to 0.015 inch.

Glass used as a structural material is exceedingly strong in compression, but very weak in tension, having a modulus of rupture of about 7,500 lbs. per square inch. By uniformly heat-strengthening the glass, as above described, its modulus of rupture can be increased to 25,000 or 30,000 lbs. per square inch; the reason for this increased strength is due to the fact that bending forces have to overcome the compressional stress in the outside layer before placing it in tension, under which condition the glass is weak and will fail.

Heat-strengthened or Tempered Safety Glass is considerably more resistant to forces that produce bending and to impact from objects not capable of cracking or penetrating the compressional layer than the parent glass from which it was made. However, it is considerably weaker to the impacts of hard objects or missiles traveling at sufficiently high velocities to break the compression layer than its parent glass. Once the compression layer is broken, the entire glass disintegrates into numerous small, friable particles. Therefore, the safety features of heat-strengthened glass depend to a large degree upon the type and size of particles of the glass when fractured.

Considering the safety characteristics of the two types of glass, those of the heat-strengthened glass depend upon the physical properties of the parent glass from which it was made; while those of laminated glass depend, not upon the properties of the glass, but entirely upon the properties of the plastic material used in its manufacture.

Briefly reviewing the history of plastics in the manufacture of laminated safety glass—eleven years ago, the only plastic material suitable and commercially available was sheets of plasticized cellulose nitrate 0.020 inch thick, commonly known as celluloid. In fact, it was the same plastic suggested by Wood back in 1905 for the manufacture of safety wind screens for automobiles.

Celluloid, as is well known, is made by colloidalizing cellulose nitrate with camphor in the proportions of 100 parts of cellulose nitrate and 35 to 45 parts of camphor.

The shortcomings of cellulose nitrate plastic for safety glass manufacture are familiar, I believe, to everyone. In 1929, the celluloid plastic available lacked clarity and stability to light and heat energy and was quite brittle at low temperatures. Any one of these characteristics was sufficient in itself to encourage organized research and development work to improve laminated safety glass.

The technical men entrusted with the development of a laminated safety glass back in 1928 that would pass the close scrutiny of the rather critical American public, were confronted not only with the problem of developing a plastic material that would be clear and as transparent as glass itself, but also with the problem of developing processes and equipment for drawing, grinding and polishing their plate glass 0.110 to 0.115 inch thick, or less than one-half the thickness of ordinary plate glass then being manufactured.

The plastic for laminated safety glass should be stable to energies in the form of light and heat, so that it would remain clear and colorless throughout its useful life and in addition have the desirable thermoplastic characteristics to insure safety features when exposed to all kinds of weather conditions ranging from sub-zero temperature in the North West to tropical climates of the South.

By 1930, we could see in the development of cellulose acetate a plastic material that would take the place of

(Left to right) Photos 3, 4 and 5 illustrate the results obtained when impacting with a 16 lb. bowling ball: (3) ordinary ¼″ plate glass; (4) laminated safety plate glass made with 0.025″ acetate plastic; and (5) laminated safety plate glass made with the Hi-Test 0.015″ plastic. The ordinary glass breaks with sharp, dagger-like particles. In (4) is seen the shearing action of the plastic due to its inability to stretch or elongate. In (5), however, the Hi-Test plastic permits the cracked lamination to bulge and thereby absorb the kinetic energy of the impacting object.

cellulose nitrate plastic and by the end of 1932, substantial quantities of cellulose acetate plastic were being used for safety glass manufacture.

This plastic was made by plasticizing or colloidalizing the proper type of cellulose acetate with dimethyl phthalate in the approximate proportions of 100 parts cellulose acetate to 80 parts of dimethyl phthalate, and was superior to cellulose nitrate plastic from the standpoint of clarity and of stability to energies in the form of light and heat. The cellulose acetate plastic used was 0.025 inch thick and the resulting laminated glass was somewhat less brittle at low temperatures and slightly more resistant to impact than laminated glass made with the nitrate plastic which it replaced.

The development and use of cellulose acetate plastic was a major contribution to the safety glass industry in that it afforded all of the safety features of the nitrate plastic, which it replaced, and in addition was satisfactorily stable for the life of the motor car. Considering laminated glass made from this plastic from the safety point of view, it was still open to the serious criticism of being brittle at low temperatures. Accordingly, research and development work on plastic materials continued unabated, investigating the broad field of plastics, including cellulose derivatives, natural and synthetic resins.

By the end of 1934, the investigation and cooperative research of the glass manufacturers, various chemical companies and plastic manufacturers, had progressed to the point where it could be predicted with a fair degree of certainty that some form of vinyl resin would eventually replace cellulose acetate plastic as the interlayer for laminated safety glass. Tests indicated that with the adoption of the vinyl resin plastic the brittle characteristic at low temperatures would be overcome or greatly improved, and further, the tough and elastic characteristics of some of the vinyl resins when properly plasticized offered a material improvement in the safety features of laminated glass at all temperatures.

Approximately four years later, substantial quantities of laminated safety glass were being made with a vinyl derivative plastic, referred to as Hi-Test plastic, and at the present time the majority of all laminated safety glass is being made with this improved plastic material in thicknesses of 0.015 inch.

The Hi-Test plastic is made by plasticizing or colloidalizing the partial polyvinyl butyr acetal with either dibutyl sebacate or triethylene glycol dihexoate, commonly referred to as 3-GH, in the approximate proportions of 46 parts plasticizer to 100 parts of the polyvinyl acetal resin.

Optical Properties of Plastics

Figure 1 shows the spectral transmission characteristics of the three plastics in the same thicknesses used commercially in sheet form for safety glass manufacture during the past ten years. As the curves show, the cellulose nitrate plastic absorbs considerably more ultra-violet radiation than either the cellulose acetate or Hi-Test plastics, accounting in a measure for the poorer light stability of the nitrate plastic. All three plastics show about the same energy absorption in the intfra-red region of solar emission and have the same transmission characteristics throughout the visible. The Hi-Test plastic, however, as the figure shows, transmits considerably more radiation in the infra-red region from 4.0 to 5.5 microns.

Physical Properties of Plastics

Considering the physical properties of the three plastic materials, both the cellulose nitrate and acetate plastics have high tensile strength; however, they do not have the ability to change their shape or physical form quickly to oppose acting forces. The vinyl acetal resins, however, when plasticized with the proper kind and amount of plasticizer, have the remarkable property of elongating under relatively low stresses until their elastic limit is reached, at which point additional stress is necessary before the plastic fails. The polyvinyl butyr acetal plastic, or Hi-Test, *will elongate approximately* 300 *per cent.*

The relative elastic characteristics of the three plastics

can be demonstrated by exerting a sudden pull on sheets of the plastic, or by impacting a sheet of the plastic stretched tightly over a drum head with a 16 lb. bowling ball.

Considering this remarkable elastic property and how it might affect the safety properties of laminated glass as compared to a more rigid or less elastic plastic; such as, cellulose acetate or cellulose nitrate plastic, when some object strikes the laminated glass with sufficient force to break the glass: If the plastic is of such a character that it will stretch or elongate, the force or kinetic energy of the blow will be absorbed or reduced by the amount of work required in bulging the plastic. If on the contrary the plastic material in the laminated glass is rigid or less yielding, such as cellulose acetate plastic, the glass under impact will first crack; but due to the fact that the plastic will not elongate or stretch readily to allow the broken lamination to bulge, the plastic will shear or fail, permitting the impacting object to pass through with possibly still dangerous momentum.

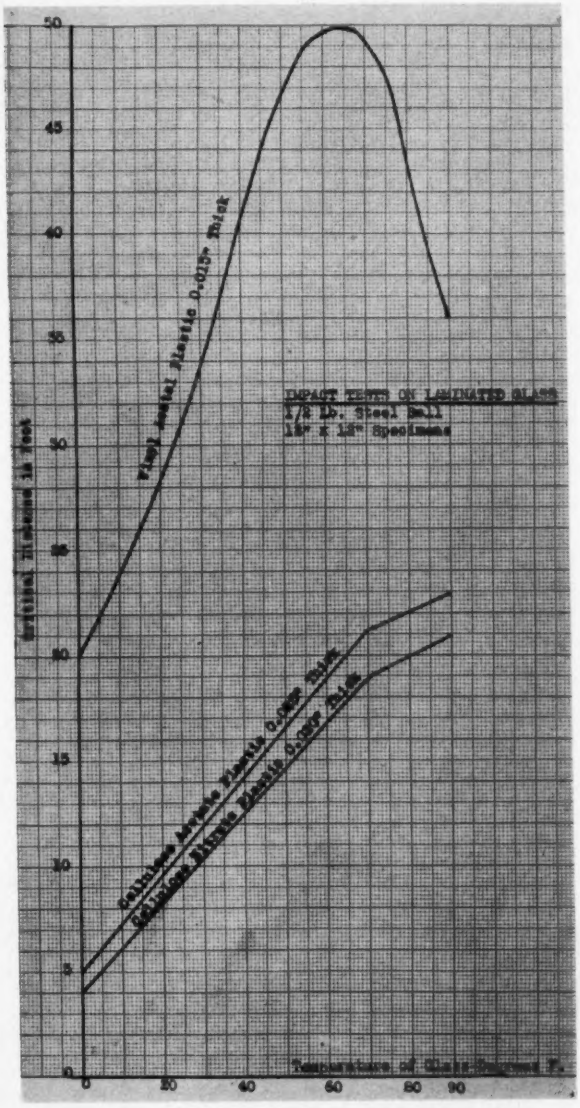


Fig 2 shows the relative resistance of 12″ square laminated safety plate glass specimens made with cellulose nitrate, cellulose acetate and Hi-Test plastics, when impacted with a freely falling ½″ steel ball at temperatures ranging from 0° to 90° F.

As the curves in Figure 2 show, laminated glass made with the Hi-Test plastic 0.015 inch thick is four times more resistant to impacts at 0° F. than laminations made with cellulose acetate plastic 0.025 inch thick; and at 70° F., the Hi-Test laminations are at least twice as resistant as cellulose acetate laminations when subjected to the same impact.

These results indicate the thermoplastic range of the Hi-Test plastic make it more suitable for laminated safety glass manufacture than either the cellulose acetate or cellulose nitrate plastics.

From the foregoing illustrations, it is certain that the Hi-Test or vinyl acetal plastic laminations will afford greater protection to the occupants of the car from the standpoint of possible injury when thrown against the glass and also from impacting objects from without, than safety glass made with a more rigid plastic.

For the present, it is not commercially feasible to use Hi-Test plastic in thicknesses greater than 0.015 inch for the manufacture of laminated safety glass; however, as production costs of the resin and plasticizers are reduced with increased use, the thickness of the Hi-Test plastic can and undoubtedly will be increased, resulting in a substantial increase in the safety features of the safety glass product.

Tests show that by increasing the thickness of Hi-Test plastic from 0.015 to 0.025 inch, the safety features, as measured in terms of resistance to impact, will be at least doubled throughout the temperature range of from 0° to 100° F.

With this type of plastic available for the manufacture of laminated glass, a safer safety glass can be realized to keep in step with the progress constantly being made in the important industry of motor transportation.

In establishing specifications and tests for safety glass for motor vehicles by different regulatory bodies, the question of the imprisonment hazard resulting from the use of safety glass has been, and still is, a much debated subject. Based upon numerous bending tests conducted on different types of glass, it can in general be said that laminated glass can be cracked easier than ordinary plate glass of the same overall thickness. After the thin plates of glass in the lamination are once cracked, the acetate plastic interlayer can be fairly easily sheared and the broken pieces readily removed from the fairly loose fitting door light runways. In case of the Hi-Test laminations, the plastic interlayer will not shear as readily as the acetate plastic; however, the layers of glass will crack more readily when subjected to bending forces. By exerting pressure after the glass plates are cracked, the plastic will act much like a hinge, making it possible to push the flexible cracked lamination completely out of the door light runways.

Bending Tests

Values for the modulus of rupture of different glasses have been determined by beam loading tests and these values are a direct measure of the resistance the different glasses would offer to breakage when subjected to bending forces and are, therefore, a measure of their resistance to escape in case of imprisonment.

BENDING TESTS ON ¼ INCH COMMERCIAL GLASS

Kind of Glass	*Effective Modulus of Rupture Lbs./Sq. In.*
Polished Plate Glass	7,500
Laminated Plate Glass, Cellulose Nitrate Plastic	6,500
Laminated Plate Glass, Cellulose Acetate Plastic	6,000
Laminated Plate Glass, Hi-Test Plastic	5,000
Heat-Strenthened Glass	25,000 to 30,000

The values for modulus of rupture indicate that heat-strengthened glass would present the greatest imprisonment hazard of all of the safety glasses and, according to laboratory tests, it would be almost impossible for the average man to break out of heat-strengthened glass, unless some sharp or hard instrument, such as a hammer, was available and could be used by the car occupants. In the latter case, the heat-strengthened glass would perhaps offer the least resistance to escape.

Considering the two types of safety glass from a research point of view, the basic variables upon which the characteristics of heat-strengthened glass depend are, as pointed out above, the inherent physical properties of the parent glass, the important properties being the relatively low thermal conductivity and the thermal coefficient of expansion of the glass; while the safety characteristics of the laminated glass depend almost entirely upon the properties of the plastic interlayer.

Looking to the future, there appears to be little hope for materially changing the coefficient of expansion or thermal conductivity of a soda-lime-silica glass that would enable us to improve the safety characteristic of heat-strengthened glass. In the case of laminated glass, however, the opportunities for further improvement are very good, since we have the broad field of plastics for research. Included in the field of plastics are the many kinds and types of cellulose derivatives, many yet to be developed and many yet to be discovered. We have the field of rubber, natural and synthetic, as well as the many resins, both natural and synthetic. Therefore, the improvements that we may expect in the future in laminated safety glass are almost infinite and will be limited only by limiting research and development work.

L-O-F OPENS GLASS SCHOOL

In order to keep its field representatives abreast of rapid developments within the glass industry, the Libbey-Owens-Ford glass company has inaugurated a jobber salesmen's training school at four of its major manufacturing plants. New products and changed methods are coming so rapidly in the industry that it has become necessary to provide special training for jobber salesmen for all sections of the country in order to keep them acquainted with improvements in their products.

Under the L-O-F training plan, the curriculum includes a study of manufacturing methods, characteristics of new glass products, proper installation methods and new uses for flat glass. The "school" opens in the world's largest window glass plant at Charleston, W. Va., on the first Monday of each month. Two days are spent at Charleston before the "students" proceed to the L-O-F vitrolite plant at Parkersburg, W. Va. After three days there, they spend a week at East Toledo and a similar period at Rossford, Ohio, where plate glass, automobile safety glass and other L-O-F products are manufactured. Teaching methods include lectures and demonstrations.

MIRROR MAKERS ADOPT CODE

The Mirror Manufacturers' Association has adopted new standards of quality. Among the provisions is one requiring all mirrors to be labeled to show whether made from plate or window glass. Labels must be affixed to all mirrors over 48 square inches and remain there until the article reaches the consumer, and will read: "This mirror is made of *Plate Glass,*" or "This mirror is made of *Window Glass.*" Another provision of the code outlaws granting or allowing rebates, refunds, discounts or credits. Numerous other provisions are designed to minimize unfair competitive practices and to enable the consumer to discriminate between mirrors of polished plate glass and those made from cheaper materials.

SOLUBILITY OF BOTTLE GLASS

Comparison of the results of studies made by different laboratories on the determination of the solubility of glass used for making bottles and similar containers led to the conclusion that some of the inconsistencies found might be attributed to the methods used for titrating the "soluble alkali."

A study of the methods recommended or in current use was made by Donald Hubbard, Edgar H. Hamilton, and Alfred N. Finn, who conclude that, all other conditions being equal, the method of titrating should be changed.

In this investigation the aqeous "extracts" of bottles were titrated with fiftieth normal acid, using the following indicators: Phenolphthalein, phenol red, brom thymol blue, methyl red, chlor phenol red, paranitro phenol, and methyl orange. At the same time that these titrations were being made, the "extracts" were also titrated potentiometrically, using the glass electrode as the indicator. It was found that the disturbing effect of carbon dioxide absorbed by the "extracts" during their preparation and titration was great enough to vitiate results, especially when the amount of dissolved alkali was small.

Since the potentiometric titrations indicated that the effect of carbon dioxide should be eliminated, a series of "extracts" were acidified with a known amount of sulfuric acid, heated, boiled under reduced pressure, and "back titrated" with fiftieth normal alkali, both colorimetrically and potentiometrically, using the same indicators as in the "direct" titrations first used.

The results in "direct titration" varied from the true value of 5.50 ml by —2.7 ml for phenolphthalein to +0.2 ml for methyl orange, while in the "back" titration the greatest differences found were —0.7 ml for methyl orange and +0.15 ml for phenolphthalein. All other indicators used gave results which varied less than 0.15 ml from the true value.

It seems, then, that unless methyl orange is used as the indicator, or the effect of carbon dioxide can be otherwise eliminated, acidification of the extract and "back" titration are to be recommended for determining the amount of alkali dissolved from glass by water. —*Technical News Bulletin, U. S. Bureau of Standards, November,* 1939.

NEW WINDOWS FOR CHINA

By SUN KUAN-HAN, J. EARL FRAZIER, and ALEXANDER SILVERMAN

Sun Kuan-han comes to the United States from China under a fellowship of the China Institute of America. Recently he submitted a thesis: "A Sheet Glass Plant for China," in partial fulfillment of the requirements for an M. S. degree from the University of Pittsburgh. From that paper, the following narrative was prepared.

The article discloses how important it becomes to bear in mind the peculiar economy of China when planning a manufacturing enterprise in that country. Though it is generally known that labor there is cheap; yet the degree to which this factor affects the design, equipping and operation of a Chinese glass plant, is quite revealing.

The conclusion of the narrative discloses figures indicating the investment required, the cost of doing business, sales values and the income to be expected from a factory such as this one. These suggest what an attractive proposition an enterprise of this kind would be for American capital. While it might appear that this part of the discussion could be relegated appropriately to an investment prospectus, it must be remembered that this article was written originally as a thesis intended to cover every phase of A Sheet Glass Plant for China. In this light, the concluding paragraphs become a truly striking feature of the narrative.

While there are plants in the various countries of the world making numerous types of glass, flat glass, especially window glass, still holds first place as far as China is concerned. In 1936, window and plate glass represented 70 per cent of a total of $10,000,000 in glass products consumed in that country. The flat glass industry may, therefore, be considered the basic glass industry for China.

There once was a window glass plant in China with a capital of $1,500,000, but it was taken by the Japanese. This left China without a window glass industry of her own, and the proposed plant will be a modest beginning towards reconstruction. At least six hundred boxes daily, or two hundred thousand boxes of single strength window glass, are required annually at the start. Even this will only provide about 6 per cent of China's total requirements.

The construction of a window glass plant in China involves problems entirely different from what an American plant would expect to experience. Raw materials must be processed in the plant itself, as this would be far more economical than if they were bought in outside markets. There are few experienced technologists in China, so information regarding the installation and operation of a plant is not easily obtained. Therefore, a plant must be self-contained, and the engineers operating it must understand everything within the plant; they should be able to erect it, operate it, and make all the necessary repairs. If nearly everything were imported, the initial cost of equipment and accessories becomes greater, time is lost before the plant can be put into operation, and later there will be delays when repairs become necessary.

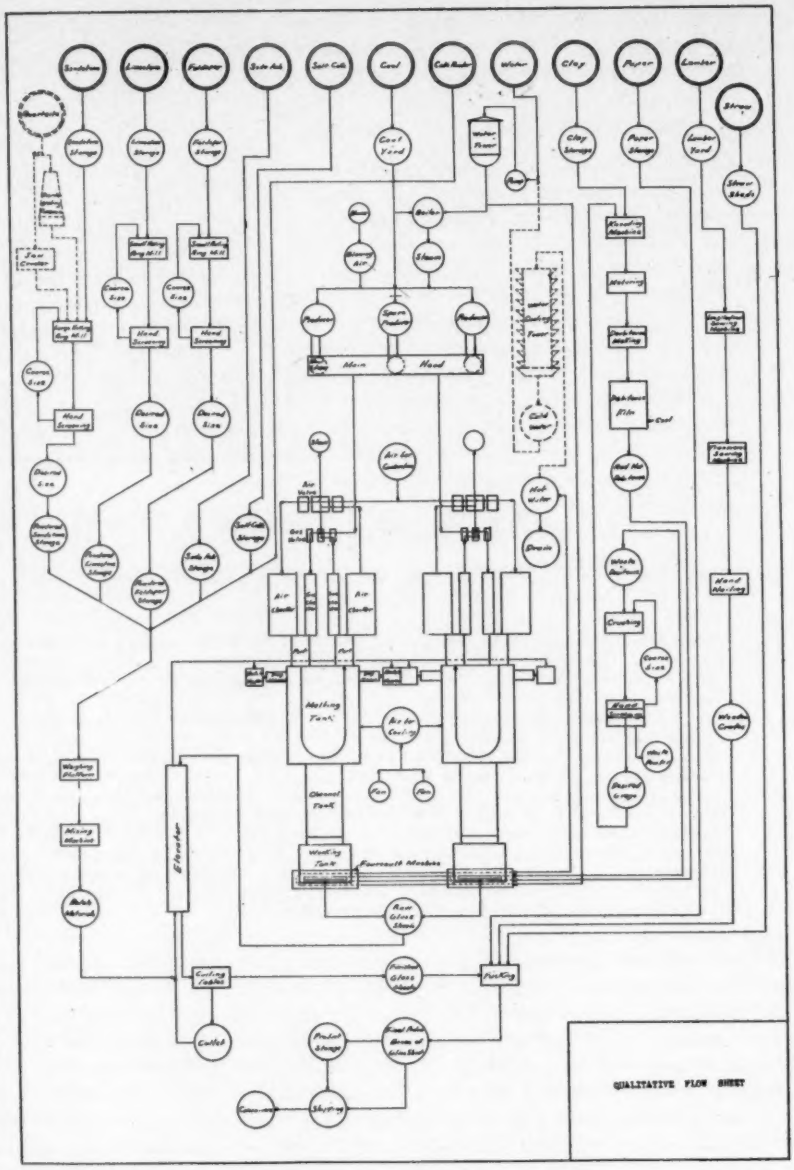
Local conditions must play an important role. In China, one uses as much labor as possible; Chinese labor is cheap, and costly mechanical devices are omitted whenever possible. Complicated machines should be avoided, for they require special care, are more difficult to repair, and their cost is frequently higher. Coal and power are not expensive in China, and therefore simple and relatively inefficient machines possess value. As many locally produced machines and materials as possible should be bought in order to reduce importation and transportation costs. Low buildings instead of tall ones are preferred, for land is cheap and construction materials are usually cheaper for low buildings.

To afford a compact picture of the related steps for operating the proposed plant, a flow sheet is provided which carries the picture from the raw materials through to the shipping room for the finished window glass. Here it is interesting to see how wasteful operation is avoided; for example, no elevator carries up a load for one purpose without bringing down a load for some other. With cheap labor available, one should note that screening, weighing, assembling of boxes, etc., are done manually whereas these operations would be entirely mechanical

in the United States of America.

Location. In view of past inroads and continued invasions the location of a plant assumes particular significance. In 1937, a careful study of the situation from the standpoint of raw materials, power, transportation, markets for finished products, etc., resulted in the choice of Changsha, Capital of Hunan Province, in the center of southern China (see map page 453) as an ideal site.

Since then, the battle front has moved to within a hundred miles of Changsha, and it may seem preferable to locate the plant farther west, in which direction there has been a migration of Chinese industries and educational and research institutions. The development of western China has been so rapid in the past two years that means of transportation are already available and power is obtainable. It is also intimated that the essential raw materials for glass manufacture with the exception of soda ash, are all available. It should, therefore, not be difficult to locate a place in the west, say around Kunming, Capital of Yunnan Province (see map), to which it seems unlikely that the Japanese will be able to penetrate.



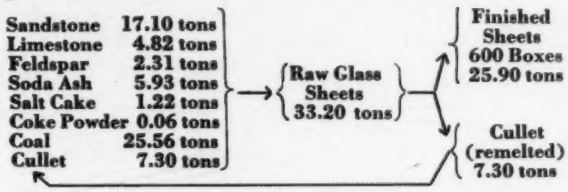
Buildings. While the detail of the buildings are not necessarily a function of the plan as drawn up, here in America, it should be mentioned that competent building designers are available in China. As has already been intimated, tall buildings are undesirable and, wherever possible, one story structures should be planned. As a glass plant operates at high temperatures, the fire hazard should be considered, especially in the furnace rooms and producer house, where concrete and steel are almost indispensable. The buildings must naturally be so placed as to permit of economical operation and expansion. Obviously, lumber yards, carpenter shops, and straw sheds must be kept away from furnace rooms. There should be plenty of water outlets and fire extinguishers should be provided freely. Studies of ventilation for the batch plant and illumination for the cutting rooms must be made.

What would never occur to us in America must also be included; namely, housing quarters for foremen and dormitories for laborers. We, who are accustomed to automobiles, buses, street cars, and local trains, can hardly realize that all these facilities are either lacking or too expensive in China and, therefore, most of the employees must live in the plant.

The Batch. For simplicity of operation it would seem best to produce a glass containing 72 per cent silica, 16 per cent soda ash, 10.4 per cent lime, and 1.6 per cent alumina. The raw materials, coal (for the glass and producers), sandstone or quartzite, limestone, and feldspar, are all available in the district selected for the plant. Even soda ash was available in a great plant in northern China, but this plant has been taken over by the Japanese. A new soda ash plant will be completed soon in western China. As Chinese hydrochloric acid is synthesized, no salt cake results; this would still have to be imported, and the soda ash-salt cake ratio may, therefore, have to be changed in the interests of local economy. If coke is needed for salt cake reduction, it can be produced locally. The clay for the making of debiteuse blocks is available, and China has plenty of lumber and straw, from either or both of which she can manufacture her paper for packing.

Taking into account the salt cake-soda ash proportions

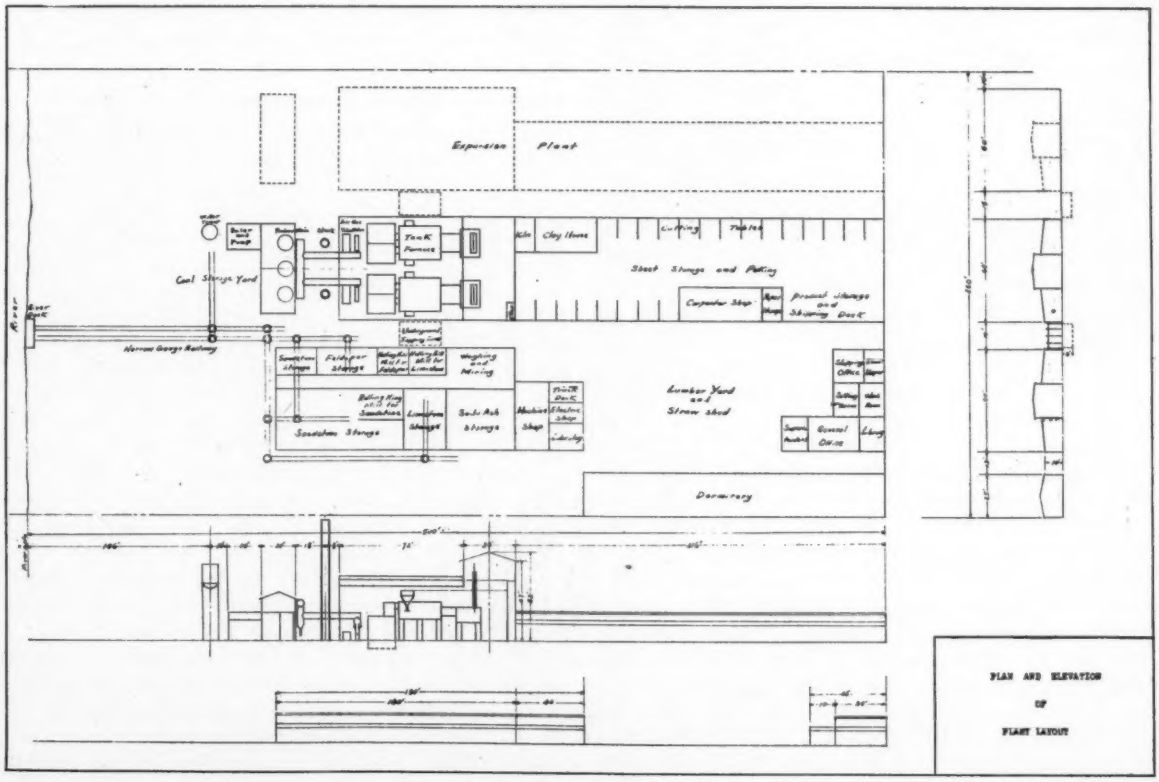
already suggested, the Na_2O ratio would be 1:5 and, therefore, the coke-salt cake ratio would have to be 0.05:1.0. The outline from raw materials to finished product follows:



The Batch Plant. Strange as it may seem to American manufacturers, no storage bins are proposed. It is planned to store all raw materials on floors, and storage rooms are designed to accomodate about a two weeks reserve supply. In the case of soda ash, a month's supply is intended. The extra time provision here is to meet an emergency in case of delayed shipment from a greater distance. Sand, limestone, and feldspar come from the mines in two to six-inch chunks and will be crushed in a rolling ring machine which automatically reduces the material to a fine granulation. The crushed products are screened by hand and taken directly to the weighing and mixing rooms, where platform scales and rotating drum mixers, the latter with a capacity of 5 tons per hour, are installed. Instead of storage bins, four batch hoppers are employed which serve for both storage and discharge over twenty-four hour periods.

Tank Furnaces. One tank furnace would be more economical to operate than two and the initial cost would be less; but we are not in America. An accident to a single furnace would shut down the entire plant. Therefore, two tanks are proposed. In fact, one of these two will be put in operation before the other is even constructed, so that any mistakes in design and construction can be remedied in the second, and so that when both operate, the shut-down of one will at least permit operation of the factory at half capacity. With these smaller tank furnaces, transverse firing would be uneconomical; hence an end port is provided which produces a horseshoe flame. A regenerative system which utilizes producer gas, made locally, yields the fuel. A recuperative system would require special tiles or tubes; these are not available in China, but the common brick of the regenerative furnace is easily obtainable. There are a number of sources of natural gas in China, but these are not always conveniently located. Oil and industrial gases are expensive. Hence, producer gas seems to be the only practical fuel. Vegetable oils are abundant; but whether they will ever prove technically suitable and economical remains to be determined.

The furnace will consist of three compartments, a melting tank with a 60° arch, a channel for refining and cooling, and a working or drawing unit. With a sufficiently long channel, floats become unnecessary. The tank will be fed through two dog-houses located on either side and heated with horseshoe flames through the end ports, as already mentioned. The channel tank will be covered with a suspended flat roof which maye be so adjusted as to raise or lower the temperature. The Four cault machines will be located above the working chamber in the customary manner. In this chamber an oil burner will serve for special heating, as needed. Dimen-



sions proposed for the three units of the tank furnace follow:

Melting Tank 14 ft. by 19 ft. by 2 ft.
Channel Tank 7 ft. by 15 ft. 8 in. by 1 ft. 2 in.
Working Tank Surface 10 ft. by 7 ft. 4 in.
Bottom 8 ft. by 5 ft. 4 in.
Depth 2 ft. 6 in.

With an assumed over-all thermal efficiency of 8.5 per cent, 0.8 tons of coal are required per ton of glass produced.

Producer Gas Plant. In this connection one immediately thinks of a mechanical producer, but its capacity would be too large for economical operation in China, where three small hand operated units are better. One producer will fire a furnace, and the third will serve as a spare. All essential parts of these producers can be obtained in China and, while the result is an efficiency lower than with mechanically operated producers, one must remember that coal is cheap in China and that its quality usually is relatively high. With a hand producer of 6.5 feet diameter, we have a coal consumption ratio of 35 lb. per square foot per hour. This is only about half the production rate of the mechanical producer, but for China this is cheaper. A gas main sufficiently large to deposit soot and prevent slowing of gas flow is provided, and a horizontal 45 horse power return-tube boiler will supply steam for the producers, as well as for other purposes in the plant.

Drawing Machines. The Fourcault machine, because of its simplicity of construction and operation, and because of its flexibility, has been chosen as the production unit; also, because of the possible smaller output. While there is a disadvantage in the use of the clay float or debiteuse, it appears to be the least complicated machine from the standpoint of repairs. Two 96 inch machines capable of producing sheets up to 3/8 inch in thickness will be installed. Window glasses of varying thicknesses are thus possible, and there is the advantage of using the heavier weights as a substitute for plate glass. Machines will be operated by constant speed A.C. motors, with a mechanical speed control for the rolls. The capacity of a 96 inch Fourcault machine is estimated at 300 to 350 boxes of finished glass per day, with each box containing 50 square feet approximating 86.4 pounds.

Debiteuse Blocks and Firing Kiln. The blocks will be prepared from grog obtained through the crushing of waste blocks in crushers used for raw materials, and a kneading machine will be provided for the grog and clay mixing. No special equipment is required except the molds.

A kiln is planned which has a capacity of two blocks and which will be fired directly on a grate by coal. The flame will travel above the debiteuse blocks and downwards to a flue escape at the bottom of the kiln, with combustion products entering a vertical stack.

Cooling of Tanks and Sheets. Two fans, each with a capacity of 17,800 cubic feet per minute, will be utilized for cooling each tank. The cooling of the sheet emerging from the debiteuse block is effected by flat water tubes placed above the block on either side and close to the rising sheet. With water entering at 70°F., the amount required for a 96 inch sheet is about 100 gallons per minute. A water tank will supply this requirement.

Cutting and Packing. About twenty-two tables will be provided for cutting. After inspection (though this is not so exacting in China as in the United States), the cut panes will be placed between sheets of paper and boxed in wooden crates, where they are protected by straw. Although the machines will operate day and night, the cutting and packing equipment is planned for day work only.

Carpenter, Machine, and Electric Shops. For cutting lumber for the crates, two sawing machines will be provided. As previously stated, the assembling will be done by hand. Asbestos rolls for the Fourcault machines will be made up in the plant, and provision will be made for the installation and repair of air, water, gas, and steam lines. A 20 foot, 16 inch, lathe; a drilling machine, a spinning machine, and grinding equipment will be provided, and a 200 H.P. transformer will be used to step down high tension current from outside power lines. Naturally, switch boards, recording meters, etc., will also be installed.

Laboratory and Library. The chemical laboratory will be equipped for the analysis of coal, producer gas and flue gas, raw materials, and finished glass. Physical equipment for the determination of density and mechanical strength will be provided. While a four-couple recording pyrometer will be used for the furnaces, a platinum-platinum rhodium couple and an optical pyrometer will be provided for use in various parts of the plant. Portable pressure recorders for producers, furnaces, flues, and stacks will also be included.

Too much emphasis cannot be laid on the importance of the library. With the isolation of China from the literary centers of Europe and America, an especially fine library should be provided for the education of individuals employed and for ready reference regarding questions which arise from time to time.

Plant Layout and Operation

The plant layout is indicated in the accompanying diagram. It consists of six buildings: a batch plant; a producer gas plant; a furnace room; the cutting, packing, and storage house; an office; and a dormitory. The arrangement is such that operation should proceed smoothly and conveniently. Most of the raw materials will be received at the water front and conveyed by hand cars on a narrow gauge railroad. Water transportation is much cheaper in China than railroad shipment. Consequently, any raw materials that can be shipped by sampan will be brought in that way. This will be kept in mind for Kunming as it was for Changsha. Minerals and soda ash will be stored on the floor of the batch plant and special yards will be provided for coal, lumber, and straw. Batch storage, as previously indicated, is avoided by having double hoppers on each furnace and carrying the batch directly to the furnaces on the elevators. On the up trip, batch is carried; on the down trip, sheets from the cut-off racks, thus effecting economy in operation. In examining the diagram, it may seem strange to see the library separated from the laboratory. The purpose in locating the library near the general offices is to have it serve the superintendent and engineer, as well as the chemists, for the laboratory is purely a control laboratory at first. (*Continued on page* 468)

MACHINE WILL MEASURE MILK
Mayor Scores Milk Cost Rise
LaGuardia Charges Big Distributors Are Seeking to Sabotage Deliveries.
Two-Quart Containers in Which Milk Will Be Delivered
2-Quart Fiber Containers Cut Milk Prices 1½ Cents a Quart
New System Announced as Mayor Denounces Rise in Rates on Bottled Product to Highest Levels They Have Reached Since 1931
New York World-Telegram
BELGIUM, HOLLAND CALL FOR PEACE
Paper Bottles to Cut Milk Bill
NOTE TO POWERS OFFERS SERVICES
2-QUART CONTAINER TO CUT MILK PRICE
SHEFFIELD FARMS SAVES YO
ON HOME DELIVERED MI
THIS NEW WAY
Mayor Attacks Milk Price Rise As 'Crime Wave'
Retail Figure to Reach Highest Level Since 1931
Announcing
ECONO-WAY
a sensational new method of home milk delivery that
SAVES YOU 1½¢
ON EVERY QUART
Originated by Borden
Econo-way

PAPER MILK BOTTLES INVADE NEW YORK

The war between the milk bottle and the paper container, which has been marked by isolated skirmishes in various cities throughout the country the past three years, assumed the aspect of a major engagement in New York City on November 9th. Hard on the heels of a price increase, announced the day before, Borden and Sheffield crashed the front pages of every New York newspaper by announcing the adoption of a new two-quart paper milk container, which they offered delivered to the consumer at a reduction of three cents. This brought the price of milk in paper 1½ cents per quart below the price of bottled milk. When one considers that Borden Farm Products Company alone, according to its president, Mr. William H. Marcussen, requires 40,000 new milk bottles every day simply to replace those that get broken, it can readily be seen what this loss of business will mean to glass container manufacturers.

The story was the big news of the day in New York City. Advertisements, up to full page size, blanketed the city's press. Not only that, but it "made" the hallowed front page—the evening dailies even used five column streamers.

At first glance, it seems incredible that a purely economic warfare between competitive containers could attract so much publicity. The answer, of course, is that milk is used by nearly every human being, poor and rich alike. And milk, on this account, is good politics. Every mayor, every alderman, is interested in hungry children, in the staffs of life of his poorer constituents.

The two-quart paper container will require a change in the habits of its protagonists. Unless they consume more milk—and possibly this may be an eventual by-product of a two quart container—the housewife will have her supply delivered every other day and will have to be more careful of her refrigeration; that is, unless she normally is a "two-quarter."

The change from glass to paper was made first on 100 Borden and 100 Sheffield routes in the Bushwick and Flatbush sections of Brooklyn, on November 13. It was announced that the boroughs of Queens, Bronx, Manhattan and Staten Island would be serviced later and in that order, the entire city to be covered by February, 1940.

(*Continued on page* 471)

INVENTIONS AND INVENTORS

United States Patents of Interest to the Glass Industry Issued During September and October.

Raw Materials and Compositions

The use of sodium cyanides and other metal cyanides, cyanates and cyanamides in glass compositions was the subject of two patents taken out by research men of E. I. du Pont de Nemours & Co. In the compositions of patent 2,174,517 (F. L. Koethen and I. J. Wernert), the purpose is to supply the element carbon. For example, in making amber glass of an ordinary soda-lime glass composition, 1 to 5 per cent of sodium cyanide would be used. It is claimed that a smaller amount of these inorganic cyanogen compounds will produce the same result as a larger amount of free carbon, or an organic carbon compound, such as starch or sugar. In patent 2,174,554 (F. J. Dobrovolny, J. M. Youel and H. E. Klein), these cyanogen compounds are used in conjunction with a copper compound in making ruby glass. Apparently such compositions are less sensitive to atmospheric conditions than ordinary copper ruby glass. This is said to eliminate the premium on control of furnace atmosphere, with the result that melting can be carried out in open pots or tanks.

William W. Shaver and Harold K. Martin of Corning Glass Works patented (2,177,336) glass cooking vessels made by a semi-tempering process which results in exceptional resistance to thermal shock. These articles are reported to have a thermal endurance which will permit their immersion in ice water from temperatures extending up to 320°C., as compared with a limit of 120°C. for untreated boro-silicate glass of the same composition. A previous objection to tempered glass for cooking vessels, has been the explosive shattering of this type of glass when fractured. According to these inventors, all of the advantages of tempered glass (chiefly a great increase in strength), can be made available for cooking vessels, by tempering so that the inner tension zone will not exceed 2.6 kgs. per sq. mm. Such a glass can be broken without explosive shattering. Apparently this discovery is applicable to types of glass other than boro-silicate glass. An example is given of a lime glass article heated to its softening temperature (695°C.) for ten minutes, and then tempered by plunging into a chilling bath of potassium and sodium nitrate at 405°C. This treatment about doubled the mechanical strength, increased thermal endurance, and yet the dish broke in a non-explosive manner.

Feeding, Forming and Shaping

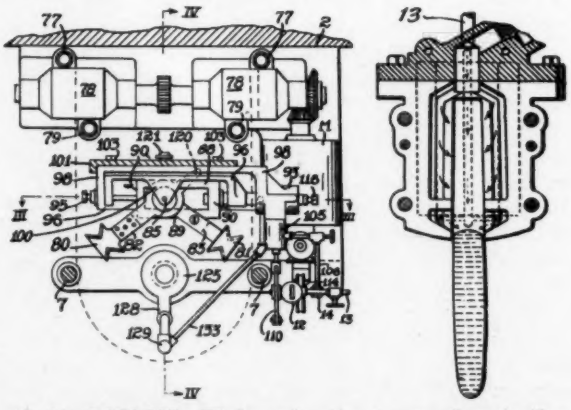
To the extensive list of feeder patents assigned by the late L. O. Wadsworth to Ball Brothers Co., are two more which have just issued. The principal features of interest in 2,174,905 are double-edged, oscillating shear blades (see illustration), which cut with one edge of each blade while moving in one direction, and with the opposite edge of the blades while returning to the starting position. Greater speed is claimed for this double-acting shear than for types of shears in which the blade or blades are successively closed and opened at each severing operation. It is stated that shear marks are not formed on the severed charges. Other features of the apparatus provide for the shearing mechanism to drop or travel with the stream at the time of severance, so as to accelerate the delivery of the charge.

The second patent granted to Wadsworth (2,172,895) claims a novel feeder apparatus of the natural flow type.

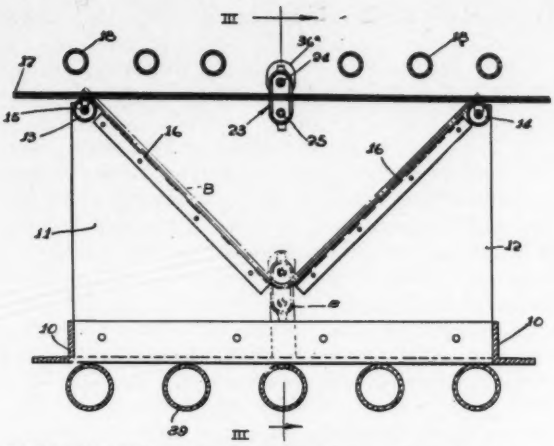
Karl E. Peiler assigned to Hartford-Empire Co., his patent 2,175,407 covering a method and apparatus for feeding molten glass. He utilizes a novel one-piece non-parting suction cup from which the charge is said to drop vertically without being thrown to one side as frequently occurs with cups which are opened to discharge the glass. (Accompanying illustration shows cup at delivery position.) Features of the method are the preshaping given the glass charge while it is elongating downward by gravity prior to release, and while the upper end only is still in contact with the suction cup.

Hartford-Empire was the assignee also of Frank O'Neill's patent 2,175,064 for a mold operating mechanism for glassware forming machines. This is a division of his application which issued as patent 2,111,296 on March 15, 1938. The mold featured in the new patent is provided with means which secure it in a closed position under sufficient pressure to resist any internal force.

A forming machine primarily for incandescent lamp bulbs was patented by Leonard D. Soubier. This is 2,174,930, assigned to Owens-Illinois Glass Co. It is stated that heretofore in making such bulbs, in order that there may be sufficient glass available for proper and uniform expansion in the finishing mold, an excess of glass was provided which left a tubular extension of the neck usually referred to as the "moile." This moile required burning off, and since it contained more glass than the bulb itself, there were considerable costs whose elimination was worth seeking. Soubier claims to have devised a machine by which the "moiles" are entirely eliminated. Measured charges of molten glass are with-



(Left) 2,174,905: Wadsworth. In a new glass feeding machine the double edged shears (80 and 81) sever a charge while moving in either direction. (Right) 2,175,-407: Peiler. This suction cup, shown here at the moment of delivery, is a feature of a newly patented feeder.



2,176,999: Miller—In a roller lehr, a pair of end supported sheets heated below their softening temperature by burners 18, are heated above softening temperature in a transverse strip by heating elements 24 and 25, and bend by gravity to take the form of the supporting table.

drawn and severed and the entire amount of each individual charge utilized in forming the lamp bulb. The details of this important machine development are too extensive to permit adequate discussion in this summary.

Randolph H. Bernard of Toledo, patented (2,172,899) a method of making glass panels for glazing which comprises moving plastic glass in the form of a relatively flat hollow cross sectional shape longitudinally, collapsing the edge of the hollow form and collapsing the hollow form transversely at spaced locations only, while the glass is plastic, so that the collapsed portions unite into seams to form hollow panels sealed around their edges.

Miscellaneous Processes

Norman R. Beck assigned his patent 2,176,241 for a lehr feeder to the Carr-Lowrey Glass Co. The purpose of this invention was to replace the practice of placing newly-shaped articles by hand on a conveyor leading to the lehr, which has created a serious problem with regard to positioning the ware in the lehr. In his new apparatus, the articles are delivered from the forming machine to a novel form of lehr feeder from which they are transferred onto the lehr conveyor in spaced rows, close to each other, but not in contact.

It has been found that bottles allowed to remain unused for a considerable period in a humid atmosphere undergo a surface leaching which brings soluble alkali to the surface. A method of preventing this action is to deposit in the newly formed hot bottle previous to annealing it, a pellet of some material, which due to the residual heat of the bottle, burns and forms an acid gas within the bottle. This method has worked well for large bottles, but it has been difficult to apply the pellets to tiny bottles, such as are used for vaccines. Toward the solution of this problem, Oscar G. Burch of Owens-Illinois Glass Co., has patented (2,175,076) a method whereby the small vaccine bottles are grouped in trays as they issue from the annealing lehr, in an orderly manner which permits the addition of about 1/20 gm. of sulphur to each, and then heating the loaded trays in an electric furnace to about 1,000°F. to burn off the sulphur.

Tongs for handling glass ware are covered by patent 2,176,251 to F. W. Duhan, assignor to Crown Cork & Seal Co., Inc.

Devices for breaking bottles to prevent their re-use were patented by Lee Burgess of Gloversville, N. Y. (2,172,496), and by Pasquale Vocaturo of New York (2,176,552), assignor to Domenico Trecasse.

Further additions to the General Electric Co's. group of glass-to-metal seal patents, were patents 2,174,374; 2,174,375; and 2,174,381. The first two were granted to James E. Beggs, and the last to Thomas A. Elder. In each, the novel features are concerned with design rather than with the composition of the seal.

Patent 2,175,019 to Donald V. Edwards of Montclair, N. J. (assigned to Electrons, Inc.), covers in a single claim, a glass of composition: Na_2O—20%, SiO_2—60%, FeO—20%, applied to sealing metal vacuum tubes.

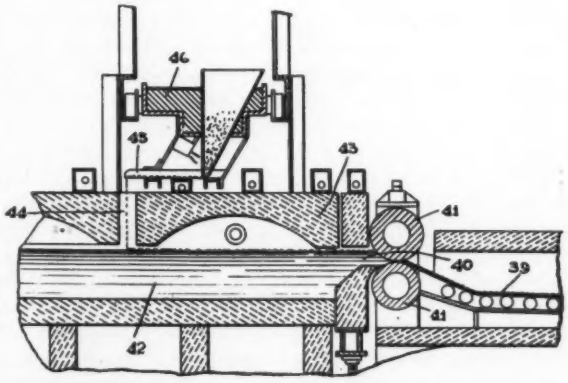
Another type of seal is covered by patent 2,175,672 to T. R. Scott and L. A. C. Pooley, London, England, which was assigned to International Standard Electric Corp. of New York. In uniting the metal and ceramic parts of electrical fittings they provide a seal mainly consisting of styrene, polymerized in place.

Plates and Sheets

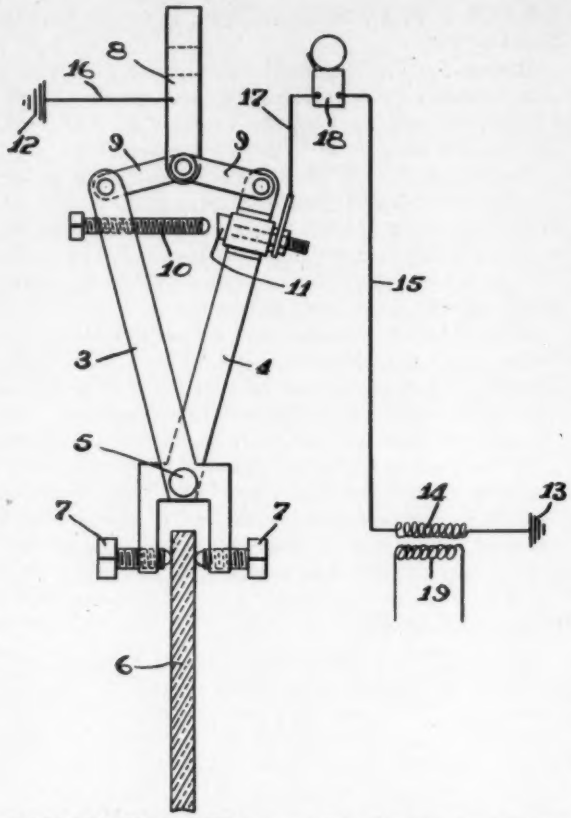
Robert A. Miller patented (1,176,999) a process and apparatus for bending glass sheets in pairs for making safety glass. Assigned to Pittsburgh Plate Glass Co., this patent is a modification of the apparatus described in an earlier Miller patent 2,033,383 of June 3, 1935. As shown in the accompanying drawing, the sheets are supported at both ends in a roller lehr and are then heated to about 200° below the softening temperature by gas burners, while electrical resistors (24 and 25 in drawing) heat a narrow band across the sheets so that they bend due to gravity to take the form of the supporting table.

Pittsburgh Plate Glass Co. was also the assignee of Arthur D. Nash's patent 2,177,000 for a process for making a coated glass sheet. (See illustration.) A glazing oxide is floated onto the surface of the glass in the forehearth, and is found to diffuse so slightly into the glass that it forms the surface layer of one side of the sheet.

Lloyd V. Black patented a device by which the softening of a glass sheet while heating for case hardening,



2,177,000: Nash.—A coloring material, fed to the glass surface in a forehearth, forms one of the surfaces of the sheet.



2,174,254: Black.—When tongs 7 penetrate to a predetermined degree into the glass sheet being heated for case hardening, an electrical circuit is closed which rings a bell to notify the operator.

allows the supporting tongs to sink in slightly. This movement is utilized to complete an electrical circuit, actuating a bell or lamp to indicate to the operator the sufficiency of the heating. (Patent 2,174,254 to Pittsburgh Plate Glass Co.)

The same company was assignee for Herman R. Marini's patent 2,176,997 covering a plastic interlayer for cementing together plates of laminated glass. It consisted of a plastic sheet of unplasticized resin sandwiched between two layers of plasticized resin, so the two latter layers could form the bond with the glass.

Frederic B. Waldron and Frank E. Slocombe assigned to Pilkington Bros., Ltd., Liverpool, England, their patents 2,176,480 and 2,176,481, for an appartus for producing ground and polished glass strip. The latter patent relates to the type of grinding apparatus, in which the rotary tools which grind top and bottom faces, simultaneously, are provided with grooves through which the abrasive passes from the center towards the periphery, with a peripheral ring to prevent the rapid escape of the abrasive. When the strip inadvertently deviates from the central position, the peripherial ring over-extends the glass strip and abrasives are lost. Since lateral deviation in the strip is bound to occur, these inventors have devised an apparatus in which the rotary grinding tools are permitted to have a compensating lateral motion, so that they will always fully contact the strip.

James G. Haworth and Chas. D. Burrell patented and assigned to Libby-Owens-Ford Glass Co., an improvement in vacuum pick-up devices for handling glass sheets (2,172,199).

Louis Gugala, of Ludington, Michigan, patented (2,171,721) a device for beveling glass plates, such as automobile glass.

In 2,177,324, assigned to American Securit Co., Bernard Long of Paris covered a novel application of tempered glass to windshields. He recites the difficulties with tempered glass for automobiles, due to the impossibility of cutting the plates without shattering the whole sheet, and mentions that when such a windshield breaks, the driver's vision is obscured by the fragmentation of the whole sheet. Long's invention consists of the provision of untempered bands across the sheet, which quarantine the shattering, and leave a free vision area. The untempered bands may be produced either by preventing their tempering, or by tempering the whole sheet and then detoughening the bands by local application of heat.

Patent 2,176,837 granted to Carleton Ellis, Montclair, N. J. (assigned to Ellis-Foster Co.), is concerned with the suspension of glass fibers in plastic compositions, for decorative effect. By dissolving resins in a solvent, adding glass fiber, and evaporating the solvent, various novel effects are obtained. Diversity is obtained by using various types of resins, and different types and colors of glass. Ellis conceived of applying coatings of such glass fiber and resin compositions to panes of glass.

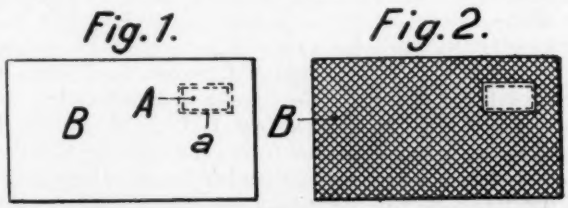
Edwin H. Land and Howard G. Rogers patented a laminated light-polarizing glass sheet in which the light-polarizing element in a typical case, was defined as "a transparent sheet of polyvinyl alcohol containing a substantially oriented light-polarizing dichroic alteration product of polyvinyl alcohol." This is 2,173,304, assigned to Polaroid Corp., Dover, Del.

Patent 2,174,183 granted to Albert L. Shaw, Corinne, Utah, is a sheet glass cutting machine and 2,174,469 to Joseph Levin of Philadelphia, is a cutting guide.

Glass Wool & Fiber

The three September-October patents involving glass fiber production and use were granted to Games Slayter who assigned them to Owens-Corning Fiberglas Corporation. Mr. Slayter is an old hand at inventions involving inorganic wools, and has made contributions of very considerable commercial importance. His best known patents are probably those which cover the common practice of blowing insulating wools into the sides of a house. This invention provided a convenient means of insulating old construction.

In patent 2,175,224, Mr. Slayter provides an electrically heated blower for use in the method of making fibrous glass which consists in passing streams of molten

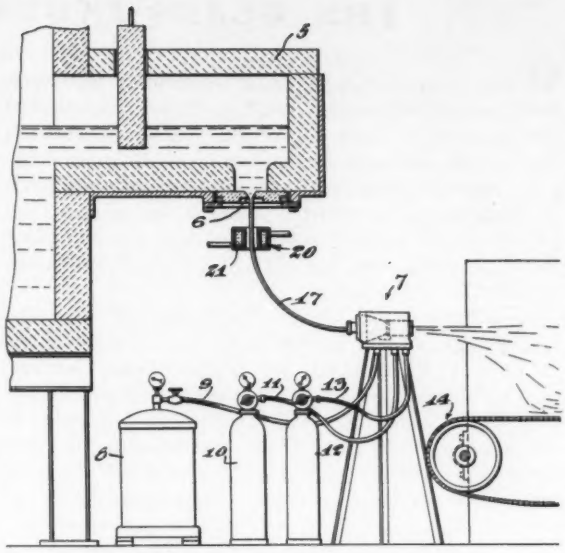


2,177,324: Long.—The small rectangular strip represents untempered glass to separate the two tempered fields A and B in a windshield; when fracture occurs in B, field A does not shatter, but is left vision-clear.

glass through a blower which applies a steam blast to draw out the fine threads. Normally, the drop in temperature is so rapid that the glass threads are too coarse for some purposes. By heating the blower and lead-in pipes, the cooling action of the steam is decreased and finer threads are produced.

Patent 2,175,225 is concerned with the same problem, that is, the excessive coarseness of fibers, due to the chilling action of the blast. Mr. Slayter's invention makes use of the "metal layer" machine by which metal wires are vaporized, so as to produce a fine spray. Glass behaves in a different manner, being drawn out into fine filaments of relatively great length. The accompanying drawing shows how this apparatus has been incorporated into a continuous process. A stream of glass drawn from the forehearth of a melting furnace is allowed to cool and harden to a wax-like consistency, and then directed while still hot into the metal layer machines, wherein it is fused by the heat of an oxy-acetylene flame and blown as fibers into a collecting room.

Slayter's patent 2,175,226 concerns a roofing shingle containing a body of glass fibers, with a backing or cover of weatherproof material, such as tarred paper.



2,175,225: Slayter.—In making glass wool a stream of glass is cooled at 20-21 to give a wax-like rod which is blown to threads in the "metal layer" machine 7, where fusion is accomplished by oxy-acetylene blast.

New Products and New Uses

A non-reflecting window is described in patent 2,172,184, assigned by Harold M. Alexander to Libbey-Owens-Ford Glass Co. The two glass plates forming the window are curved in a horizontal plane so that the axes of the bends and their line of contact are vertical.

Many types of window construction and mountings were dealt with in patents issuing in September and August. Double pane windows were described in Pittsburgh Plate Glass Co. patents 2,174,279, Edward F. Toney, and 2,177,001, Wm. Owen. A basement window form was patented by F. F. Beil and Sern Madsen of Curtis Companies, Inc., Clinton, Iowa (2,177,201). A supporting frame for large plate glass windows was patented by J. I. Haskel of Stockholm, Sweden (2,177,037).

Other types of windows and window construction were described in the following patents: 2,174,781 and 2,175,909 to Oliver M. Edwards and Russell B. Nelson respectively of the O. M. Edwards Co., Inc., Syracuse; 2,175,861 to Frank E. Wall, assignor to Gabriel Steel Co., Detroit; 2,173,664 and 2,173,649 to L. W. Shutts and W. B. Firner, respectively of General Motors Corp., Detroit.

An improved type of glass wall construction was claimed in 2,176,654 granted to Paul G. Masters, Huntingdon Valley, Pa., and assigned to Penna. Wire Glass Co. of Philadelphia.

Patent 2,176,012 to A. H. Payson and C. O. Duevel, Jr., assignors to the American Thermos Bottle Co., Norwich, Conn., is a vacuum bottle.

Alexander Stein of Ventnor, N. J., patented a footed drinking glass holder containing a light bulb and dry cell (2,177,337).

Patent 2,177,396 to John F. Watson, assignor to the Borden Co. of New York, is concerned with the now familiar type of milk bottle on which there is a flange to be covered by a cap of pliable metal, which is easily removed after being turned.

Ten patents were issued for bottle closures. These were 2,172,544; 2,172,644; 2,173,030; 2,173,098; 2,173,570; 2,173,785; 2,174,378; 2,176,317; 2,176,395; and 2,177,310.

CORNING TO EXHIBIT AT CHEMICAL SHOW

The Corning Glass Works will be one of the larger exhibitors at the Chemical Industries Exposition to be held at the Grand Central Palace, New York, the week of December 4. Among the newer developments in Pyrex-ware will be shown the all-glass Nash centrifugal pump. The Corning exhibit also will depict pictorially the progress made from early days to the present.

LEMONADE FOR HEAT FAG

In the March, 1939, issue of "Occupational Hazards and Safety," N. C. Deering, in an article entitled, "Salt Conditioning Against Heat Fag," writes as follows:

"Characterized by symptoms ranging from dramatic collapse to minor cramps and lassitude, heat fag is a year around hazard for workmen in the high temperature operations of several industries. Heat cramps or heat fag is the manifestation of deficiency of NaCl, sodium chloride or salt, one of the 18 primary mineral salts which, with calcium and water, are the chief constituents of the body. Particularly susceptible to loss and consequent disturbance of normal balance is sodium chloride, by virtue of its admixture with skin secretions and its evaporative release."

Salted-drinking water is probably one of the least palatable of drinks. Recognizing this fact, the F. E. Reed Glass Co. of Rochester, N. Y., now provides its employees with lemonade to which is added salt in the necessary amounts to overcome heat fag. This novel innovation has met with great enthusiasm from employees. Trujuis, quick-frozen fresh lemon juice paced by California Consumers Corp., Los Angeles, is being used by the F. E. Reed Glass Co., for making its lemonade.

THE GLASS INDUSTRY IN OCTOBER

October was one of the most outstanding months in recent years for the glass industry. Production reached the highest point since August 1937. Payrolls were up, employment increased, exports set a new record and imports were considerably below their usual seasonal level. All branches of the industry shared in the increased domestic and foreign trade volume and there are indications that several more new records will be established before the year is completed.

According to GLASS INDUSTRY's Production Index, the total output of glass in October attained a value of approximately $33,000,000, the highest figure for any month since August 1937. This represents an increase of 20 per cent over September, and of 35 per cent over the same month of 1938. Total production for the first ten months of 1939 has exceeded a value of $260,000,000, which is 30 per cent better than 1938 and within 15 per cent of 1937.

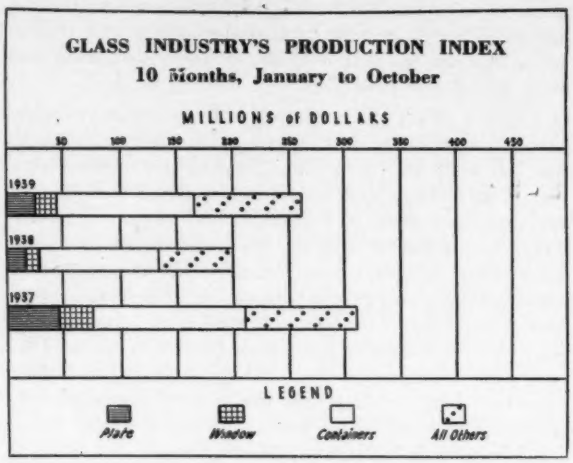


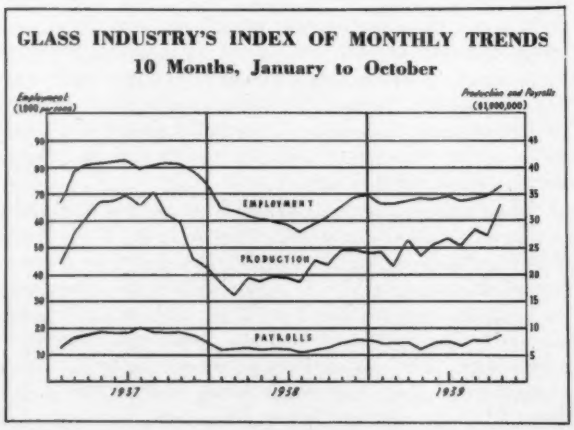
Plate Glass output during October totaled 18,369,000 square feet, according to the monthly report of the Plate Glass Manufacturers of America. This represented a 34 per cent increase over the previous month and a 43 per cent gain over October of last year. It was the largest monthly volume since June 1937. Ten months' figures of plate glass activity indicate that 1939 is running almost 80 per cent ahead of 1938 but is 37 per cent below the 1937 level.

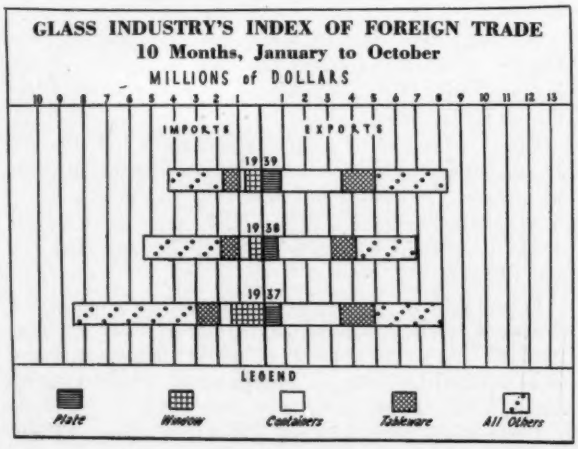
Window Glass production during October amounted to 1,121,000 boxes, according to the monthly report of the Window Glass Manufacturers Association. This represented a 23 per cent increase over the previous month and a 75 per cent jump over October of last year. This activity reached the highest point in two years, exceeding all monthly totals since October 1937. During the first 10 months of 1939, window glass output exceeded the comparable 1938 volume by 78 per cent, but was 27 per cent less than the 1937 total.

Glass Container production during October totaled 4,891,000 gross which was 15 per cent ahead of September and 27 per cent more than October 1938, according to the Glass Container Association. This output was larger than in any previous month since August 1937 which indicates that for the first time monthly activity in this industry has run ahead of the industry's record year—1937. Shipments during October amounted to 4,471,000, which was about 12 per cent above the comparable periods of 1938 and 1937. The high production rate was necessary to take care of these shipments and to build up the low inventories resulting from the record shipments in September.

Miscellaneous Glass Products produced during October exceeded $10,000,000, according to estimates from reliable sources. This represented an increase of about 20 per cent over September and more than 30 per cent over October of last year. A spurt in illuminating ware output running up to 30 per cent accounted for part of these gains, while other pressed and blown glassware plants reported activity surpassing that of any recent year. Some manufacturers of tableware compared this fall's remand with the immediate post-repeal era. The generally increased buying power of recent months has been doubly effective in this industry because of the curtailment of imports resulting from the European war.

Employment and Payrolls: According to the United States Bureau of Labor Statistics, approximately 70,000 wage earners were employed in the glass industry during





September. It is believed that at least 2,500 more workers were added during October, bringing that month's total to about 72,500. This represents a net gain of 7,500 persons over October 1938, but indicates that about 8,000 more must be hired if 1937's employment figures are to be equaled.

Revised indices of the Bureau show that about $7,700,000 was paid to wage earners in the glass industry during September; trade reports indicate that almost $1,000,000 was added to this payroll in October. It is estimated that during the first ten months of 1939 the nation's glass payroll totaled $73,000,000 as compared to $61,000,000 in 1938 and $87,000,000 in 1937.

Foreign Trade: United States foreign trade in glass was valued at nearly $1,800,000 in October—approximately 12 per cent ahead of the same month last year. The nature of this trade has changed drastically, however, for exports have jumped 70 per cent from $800,000 to almost $1,400,000, while imports have declined 45 per cent from $754,000 to $418,000. On a ten months' basis, 1939 exports were 23 per cent above 1938, while imports were 20 per cent below.

American manufacturers and exporters of glass products continued to expand their foreign sales during October, exceeding even September's record totals. The current level of this trade is higher than the 1929 period and is equal to the immediate post-war years. All types of glass are selling in increasing quantities abroad with largest per cent gains noted in the window glass trade. On a volume basis, October plate glass exports showed the largest increase over September, while container and tableware shipments are shown to be setting the pace when comparisons are made with last year's trade. Export prospects for glass are the brightest in recent years. (See Foreign Trade Opportunities on this page.)

Many observers will be surprised to note that preliminary returns show imports of glass products during October were 7 per cent ahead of September. This was 45 per cent below last year's level, but indicates that shipments are coming in in sizable amounts despite disturbed conditions abroad. However, since these statistics include withdrawals from warehouses, it is possible that actual arrivals from abroad were smaller than the figures suggest. Tableware imports increased 40 per cent over September, but were 2 per cent below October 1938; on a ten months' basis they were 10 per cent under last year's figures. Sales of foreign-made window glass dropped 28 per cent from September and 31 per cent from last October, but for the first ten months they have increased 12 per cent over 1938.

FOREIGN TRADE OPPORTUNITIES

Below is a list of recent inquiries received at the Specialties Division, Bureau of Foreign and Domestic Commerce. Those interested should write immediately to H. B. McCoy, chief of the Division, specifying the reference numbers of any inquiries they wish to contact.

Reference Number	*Commodity*	*City and Country*	*Purchase or Agency*
4291	Opalescent and structural glass	Sydney, Australia	Agency
4298	Window glass	Lime Peru	Agency
4302	Low-priced glassware	Lime Peru	Agency
4453	Glass tumblers	San Jose, Costa Rica	Agency
4418	Window glass	Lima, Peru	Agency
4461	Crystal glassware	Lima, Peru	Agency
4388	Glassware	Guayaquil, Ecuador	Agency
4451	Unbreakable glassware	Santiago, Chile	Both
4457	Glassware	Cairo, Egypt	Agency
4371	Glassware	Caracas, Venezuela	Agency
4454	Pharmaceutical bottles	Habana, Cuba	Agency
4388	Bottles and flasks	Guayaquil, Ecuador	Agency
4357	Perfume and liquor bottles	Ciudad Trujillo, Dominican Republic	Agency
4460	Glass containers, tableware	Managua, Nicaragua	Agency
4297	Milk bottles	Lima, Peru	Agency
4542	Glassware	San Jose, Costa Rica	Agency
4540	Glassware	Cali, Colombia	Agency
4611	Glassware	Caracas, Venezuela	Agency
4565	Window glass	Rio de Janeiro,	Agency
4633	Glass ampules and syringes	Mexico City	Purchase
4635	Glass ampules and tubes	Mexico City	Purchase
4626	Glass bottles, containers, illuminating ware	Cartagena, Colombia	Agency
4663	Household glassware	Johannesburg, S. Af.	Agency
4650	Glassware	Bogota, Colombia	Agency
4790	Cosmetic bottles and jars	Johannesburg, S. Af.	Agency
4776	Glass ampules	Amsterdam	Both
4766	Crystal glassware	Melbourne	Both
4781	Window glass and mirrors	Asuncion, Paraguay	Purchase
4783	Plate glass store windows	Batavia, Java	Both
4774	Glassware	Tegucigalpa, Hond.	Purchase
4778	Glassware	Mexico City	Agency
4790	Glassware	Johannesburg, S.Af.	Agency
4784	Refrigerator dishes	Batavia, Java	Purchase
4772	Glassware	Habana, Cuba	Agency
4940	Bottles	Cairo, Egypt	Agency
4934	Ampules and thermometers	Rio de Janeiro	Agency
4793	Window glass	Buenos Aires	Agency
4872	Scientific glassware	London, England	Purchase

UNITED STATES FOREIGN TRADE IN GLASS

(Values in Thousands of Dollars)

Commodities	*1939 September*	*1939 October*	*1939 Ten Months*	*1938 October*	*1938 Ten Months*	*Percentage Change Sept.-Oct.*	*Percentage Change Oct.-Oct.*	*Percentage Change Ten Months*
EXPORTS								
Plate	149	197	883	74	629	+ 32	+166	+40
Window	3	10	40	2	29	+233	+400	+38
Containers	391	427	2,756	251	2,378	+ 9	+ 70	+16
Tableware	215	211	1,561	156	1,297	— 2	+ 35	+20
Illuminating Ware	42	57	369	44	334	+ 36	+ 30	+10
All Other	360	456	2,716	274	2,117	+ 27	+ 66	+28
Total	1,160	1,358	8,325	801	6,784	+ 19	+ 70	+23
IMPORTS								
Plate	6	9	57	16	88	+ 50	— 44	—35
Window	60	43	703	62	629	— 28	— 31	+12
Containers	15	25	269	58	462	+ 67	— 57	—42
Tableware	62	100	749	98	831	+ 40	— 2	—10
Illuminating Ware	22	6	338	50	504	— 27	— 88	—33
All Other	226	174	2,037	470	2,776	— 23	— 63	—27
Total	391	418	4,224	754	5,290	+ 7	— 45	—20

ESTIMATION OF BORON IN GLASSES—A FLAME TEST

The increased use of borax in all types of glass batches makes it highly desirable that the glass chemists have a simple, rapid and accurate method for the detection and estimation of the boric oxide content of glasses.

The classical flame test in which a mixture of powdered glass, potassium bisulphate and calcium fluoride is placed in the non-luminus flame of a Bunsen burner by means of a platinum loop and noting whether or not a green flame appears has long been used as a qualitative test for boron. Stahl[1] has taken the basic principle of this technique and has developed a procedure through which a quantitative measure of boron may be obtained by comparing the intensity of the green color of the unknown in the flame with the color produced by a comparative sample.

Weber and Jacobson[2] have recently modified this procedure of Stahl's in such a manner that both rapidity of procedure and fairly accurate results may now be obtained by flame methods. The equipment used in their modified flame test is shown in Figure I.

In this apparatus, air passes at a rate of 150 cc. per minute through a calcium chloride drying tube and a flow meter into the bottom of the test tube where it bubbles through 7 cc. of liquid which contains the boron sample. A mixture of air, alcohol vapor and methyl borate passes out the top of the test tube, through the nozzle, and then through the thin part of a fan-shaped Bunsen flame where the mixture ignites and burns with a green flame. The duration of this green color is proportional to the amount of boron present. Data obtained by Weber and Jacobson indicate that while the intensity of the color rapidly diminishes when the boron content reached is 0.03 mg. the total time of duration of color is almost a straight line function of the boron content up to about 0.10 mg. Typical results are shown in Figure II.

In the case of glass the solution through which the air is bubbled is prepared as follows: the powdered glass sample is fused in a nickel crucible with potassium carbonate and the fusion dissolved in distilled water. A suitable aliquot is then taken and evaporated nearly to dryness. One cc. of concentrated sulphuric acid and 6 cc. of methyl alcohol is added and the solution placed in the test tube. It is claimed that even on glasses containing less than 1 per cent of boric oxide, checks of 10 per cent or better may be obtained by the method.

It is possible that the use of a graph similar to that shown in Figure II and prepared by determining the flame duration times of suitable standard solutions of varying boron content would make this method very suitable for plant control work. After such a graph is once prepared the flame duration time of a glass can quickly be determined and its boron content found by the use of the graph.

Such standard solutions could easily be obtained, for example, by taking the Bureau of Standards standard glass sample No. 128 (which contains about 1.5 per cent boric oxide) and preparing a master solution. Suitable aliquots will give any range of boric oxide content desired.

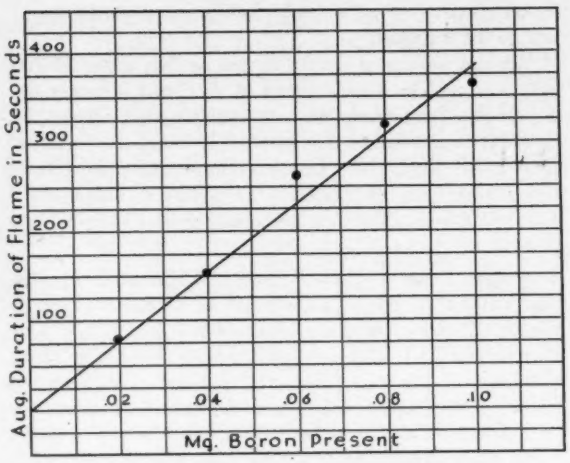


Fig. 2. (Taken from Weber and Jacobson's data.)

[1]Stahl, W. Z., anal. Chem. 83, 268-88 (1930); 101, 342-7, 348-56 (1935)
[2]Weber, H. C. and Jacobson, R. D., Ind. Eng. Chem. Analysis Edition 10,273 (1938)

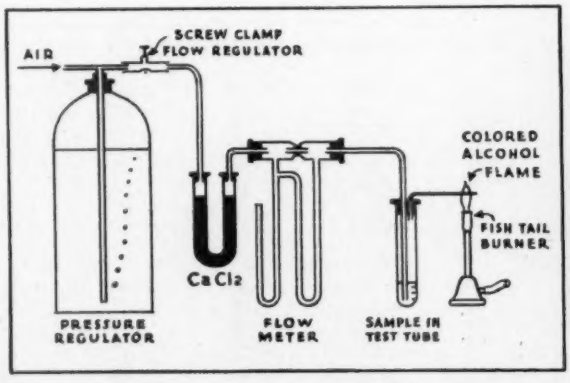


Fig. 1. Apparatus used by Weber and Jacobson in Flame Test for Boron.

A view of "Elmsford," the new home of the Society of Glass Technology, recently received from England. The foundations of this lovely structure were laid just two years ago November.

EQUIPMENT AND SUPPLIES

CATALOGS RECEIVED

Cambridge Wire Cloth Co., Cambridge, Md. "Metals and Alloys." Bulletin 76. A 32 page booklet of unusual scope and character that meets the demand for information concerning the properties of various metals and alloys available in fabricated forms such as woven wire cloth, wire screens, filter cloth, spiral woven wire conveyor belts and numerous other metal products. The booklet is well illustrated, and particularly noteworthy is a table several pages in length, listing the relative resistance of different stainless steels to chemical attack. The work inspires confidence and warrants inclusion in the library of every plant engineer.

Precision Scientific Co., Chicago. Bulletin 305. An eight-page bulletin containing a practical discussion on the subject of heat transfer as applied to constant temperature laboratory equipment. The first six pages are devoted to reviewing briefly principles of heat transfer and to outlining technical considerations affecting rate of heat transfer, variations in quantity of heat required, attributes of peak performance, and other aspects of efficiency. The remaining pages are devoted to the Precision-Freas line of laboratory equipment for controlling heat.

Stephens-Adamson Mfg. Co. Catalog 1339, containing up-to-the minute information on the company's car pullers, hoists and sheaves, and on certain hand and motor operated winches. Included is the new No. 14 Wire Rope Car Puller, and a new section on rope for S-A car pullers.

R. W. Rhoades Metaline Co., Inc. Long Island City, N. Y. "Oilless Bronze Bearings." Describing the various types of oilless bronze bearings which this company has been making for more than half a century. Of special interest to plant maintenance men and machinery designers.

A. P. Green Fire Brick Co., Mexico, Mo. New 8-page, illustrated booklet describes various types of firebrick, including data on composition, testing and application.

Eclipse Air Brush Co., Inc., 390 Park Ave., Newark, N. J. Four-page folder catalogs complete line of air-motored agitators, both direct and gear driven, for use with paint spraying equipment.

CATALOG & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins reviewed in this department may be obtained by writing to THE GLASS INDUSTRY.

Porter-Cable Machine Co., Syracuse, N. Y., have published a bulletin describing one of their latest machines, the Wet-r-Dry Grinder which is used for rough grinding and finishing of glass and other materials of a similar nature.

North American Refractories Co., Cleveland, Ohio. "Cements and Plastics for Every Refractory Use" is the title of a publication just issued by this company. Colorfully and amply illustrated, the data on this material is presented in concise, readable form.

Chicago Eye Shield Co., 2300 Warren Blvd., Chicago, Ill. New 48-page book entitled "Industrial Head and Eye Protection" lists and describes complete line of goggle, respirators, spectacles, masks, welding helmets and other safety devices. Illustrated.

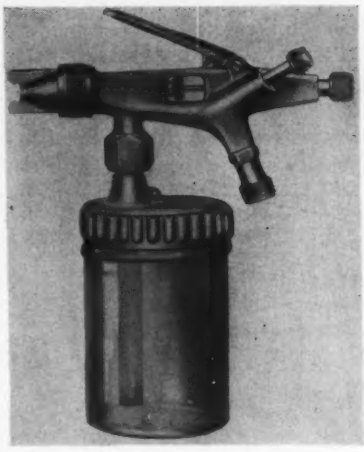
Ingersoll-Rand Co., Phillipsburg, N. J. Form 1917—A new broadside describing the company's general service motor-pump which is built in sizes for delivery of from 5 to 1,000 g.p.m. and heads up to 500 feet.

RATE OF FLOW INDICATOR

A NEW Rate of Flow Indicator, named the MJL 98, has been announced by Morey & Jones, Ltd., Los Angeles. The indicator is of the differential pressure type and will indicate the flow of liquids, steam and gases; or the level of liquids, as in boilers or tanks, whether or not under pressure. When used for the former purposes, the instrument is actuated by the differential pressure produced by a primary device such as an orifice, venturi tube, or pitot tube, inserted in the pipe line. The differential pressure is balanced by a calibrated bellows unit which moves in direct relation to the pressure applied. This movement is transmitted to a pointer and, since the flow varies as the square root of the differential pressure, the scale may be furnished to read directly in any units of flow desired, simply by using a square root scale of suitable range.

The calibrated bellows unit eliminates the conventional mercury column, thus removing any possibility of contamination to the fluid in the line, by the mercury itself, or of injury to copper or brass fittings with which mercury amalgamates. Since the mechanism responds instantly to changes in flow rate, or differential pressure, and has a relatively small displacement, practically no accumulated error will result in the readings, although the leads to the instrument are throttled in order to reduce the effect of surges or pulsation in the line.

Either high or low alarm contacts, or both, may be supplied to operate a signaling device when the flow or liquid level reaches any predetermined point.



DE VILBIS ANNOUNCES NEW SPRAY GUN

THE DE VILBIS COMPANY, Toledo. has perfected a new type of spray gun; specially adapted for the glassware and ceramic industries, which is to be known as the Type AG. The new gun will bridge the gap between the artists' air brush and the small production or touch up spray gun, with a range of service extending from the drawing of a fine pencil line to laying a broad soft spray three inches in width. This makes it ideal for delicate tinting, fine stenciling, shading, blending and highlighting. Three nozzel combinations are available and these are adjustable for either round or fan spray applications, with accurate and simple control of both width and density of the spray. While built to endure, the spray gun is light in weight, fits the hand easily, and is designed to permit the forefinger to rest naturally upon the trigger.

CONTROLS FURNACE ATMOSPHERE

Definite control over atmospheric conditions in the heating chamber of the oil fired furnace is now possible by a new device, the Air-Oil Ratiotrol, according to an announcement by the North American Manufacturing Co., Cleveland, makers of this equipment. The Ratiotrol accurately proportions the flow of fuel oil and its combustion air by controlling pressures and making them dependent upon each other. The air pressure alone becomes the dominant factor, while the number of burners and their individual settings have no effect upon the operation. A constant atmosphere is maintained despite fluctuations of oil or air pressure, varying rates of fuel input, or the manipulation of individual burners. The announcement states that several months' test under actual plant operating conditions have been made in the steel industry, where definite savings in fuel consumption have been recorded.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	43.00	46.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)	lb.	....	....
Granulated	In bags, lb.	.0215	.027-.0295
Powdered	In bags, lb.	.024	.0295-.032
Boric acid (H_3BO_3) granulated	In bags, lb.	.048	.054-.0565
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite (Na_3AlF_6) Natural Greenland (Kryolith)	lb.	.0865-.0875	.0925
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	30.00-31.00	....
In bags	ton	31.60-32.60	42.00-45.00
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0755	....
In 5 Ton lots	lb.	....	.08½
Less than 5 Tons	lb.	....	.09
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	8.50	8.50
Burnt (CaO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	9.00
Burnt, ground, in 180 lb. drums	Per drum	1.60	1.70
Kiln Dried ($CaCO_3$) 10x30 mesh	ton	1.75	....
Kiln Dried ($CaCO_3$) 16x120 mesh	ton	1.75	....
Nepheline Syenite, f. o. b. shipping point	ton	12.00-14.00	....
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	25.00
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. 95% and 97%	Per 100 lb.	....	2.50-2.90
Bulk	Per 100 lb.	1.35	....
200 lb. bags		1.415	1.44
100 lb. bags		1.45	1.475

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.029	.03½
Aluminum oxide (Al_2O_3)	lb.	.07	.09
Antimony oxide (Sb_2O_3)	lb.	No supplies available.	
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03	.03½
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite, (20% Al_2O_3)	ton	9.00	12.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.05¾-.06	.06¼-.06½
Tin Oxide (SnO_2) in bbls.	lb.	....	.52
Titanium Oxide (ceramic grade)			
In bags	lb.	.12	.12¼-.12¾
In barrels	lb.	.12¼	.12½-.13
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06¼	.06½
White Seal, 150 lb. bbls.	lb.	.08¼	.09
Green Seal bags	lb.	.08	.08¼
Domestic White Seal bags	lb.	.08½	.08¾
Red Seal, bags	lb.	.07½	.07¾
Zircon			
Refined Granular (Milled .01-.02c higher)		.06½	.07-.08

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	.95
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.22-.25
Chromite (99% through 200 mesh)	ton	35.50	40.00
Chromite ore (air floated)	ton	55.00	58.00-73.00
Cobalt oxide (Co_3O_4)			
In bbls. 350 lbs. or more,	lb.	....	1.84
Less than 350 lbs.,	lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.165
Black (CuO)	lb.	....	.18-.19
Black prepared	lb.	....	.22
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.0425-.09
Black (Fe_3O_4)	lb.	.04½	.09
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls.	lb.	....	.145
Manganese, Black Oxide			
In Paper bags	ton	62.50	65.50
In Burlap bags	ton	64.25	67.25
In Casks	ton	66.50	69.50
Neodymium oxalate, 50 lb. drums	lb.	....	3.50
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	.08¾	.09-.09¼
Powdered	lb.	....	.09¼-.09¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.18-.20
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06¾	.07-.07¼
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	.08½	.08¾-.08¾
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65.
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.75-1.80
Yellow	lb.	....	1.75-1.80
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	....	2.65-2.75
Yellow orange	lb.	....	1.75-1.80

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.063	.07
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	.03
0, 0½, ½, 1.	lb.	....	.04
Putty Powder	lb.	Open price.	
Rotten Stone, (Domestic)	lb.	....	.03½
Rouge, Red	lb.	....	.16
Black	lb.	....	.18

A SYMPOSIUM ON TEMPERATURE

(*Continued from page* 442)

The troublesome problem of measuring the temperature of bodies that do not radiate like a black body was discussed and the corrections for reducing such readings to the true temperature were given for a number of different materials.

The Fluorescent Mercury Vapor Lamp as a Light Source for a Single Point Check on Optical Pyrometers. *By C. F. Lucks and H. W. Russell, Battelle Memorial Institute.*

In cases where an optical pyrometer is used quite frequently and accurate readings are required it is desirable to have a dependable light source for making a quick and convenient single point check on its accuracy. The authors have studied the 15-watt pink fluorescent mercury vapor lamp and from their results have shown that its general characteristics make it very suitable for such use.

The apparent brightness temperature of the pink fluorescent lamp operating with an auxiliary on a standard 110-120 volt a.c. circuit is approximately 2000° F. (Editor's note: This is a very suitable check point for standardizing optical pyrometers used for determining "gob" temperatures.) A change of 5 volts in the line voltage was shown to cause a change of about 15° F. in the apparent brightness temperature of the lamp.

In a study of the life of the lamp it was found that up to the last 175 hours of operation there is only a relatively small decrease in the apparent brightness temperature. Over an interval of one hour the average decrease is considerably less than the precision of the ordinary optical pyrometer. This investigation also included a study of the effects of both intermittent and continuous operation of the lamp and the effect of room temperature.

Flame Temperature. *By Bernard Lewis, Bureau of Mines, and Guenther von Elbe, Carnegie Institute of Technology.*

This discussion was confined to flames produced by fuels used for heating and for the generation of power. The theoretical flame temperature corresponding to complete statistical equilibrium in the burned gas is distinguished from the experimental flame temperature measured by the gas law equation and corresponding to equilibrium in the translational degrees of freedom. Experiments on fast flames in closed vessels showed that the latter may be higher than the former due to excitation lag in the internal, presumably vibrational, degrees of freedom.

The line-reversal method of determining flame temperatures is based on the assumption that on introducing certain metal vapors into a flame, statistical equilibrium is established between the electronic degrees of freedom of the metal atoms and the flame gases. The metal atoms thus emit and absorb their 2 pectral lines as thermal radiators. The principle of the method is as follows: If a black body is placed behind a flame, colored for example with sodium, and a spectroscope is sighted through the flame onto the black body, there will be some temperature of the latter at which its brightness in the spectral region of the D lines equals the brightness of the light transmitted in this region through the flame plus the brightness of the D lines from the flame itself. At this temperature only a continuous spectrum of the black body is visible in the spectroscope. At a lower temperature of the black body the sodium lines appear bright by contrast against the continuous spectrum. At higher temperatures, this contrast reverses itself. The temperature of the flame is then identical with the reversal temperature.

The technique of measuring flame temperature by wires and thermocouples was also described. In the case of the measurement of flame temperatures by infra-red radiation, temperature variation within the flame was shown to be a disturbing factor.

It was pointed out that soot-forming luminous flames may be regarded as being in complete statistical equilibrium, the temperature difference between soot particles and the surrounding gas being negligible. Methods of determining the temperature and emissivity of such flames were described.

In industrial furnaces the differences between the experimental and theoretical flame temperatures should be negligible and there is thus no reason to question the existence of a true temperature.

The flame temperatures of various combustibles and the change of flame temperature with the air-fuel ratio can be compared by using the vast amount of line-reversed data that has been compiled by Lewis and von Elbe.

FRANK E. TROUTMAN

With extraordinary and unexpected suddenness, there passed away on November 16th, Frank E. Troutman, at the age of 54. He is well known in the plate glass industry as a former president of the "old" Standard Plate. The members of the Glass Division of the A.C.S. will remember him as a Vice President of the Woodmont Rod and Gun Club, who accompanied them at their summer meeting at Woodmont a few years ago. By all his friends and acquaintances he will be remembered as one a little too unselfish for this world, generous to a fault, steadfast and uncomplaining under a succession of adversities and frustrations such as fall to few men, a great sportsman and a thorough gentleman.

• Dr. Carl H. Zwerman has been apponted acting head of the Department of Ceramic Engineering at the University of Washington, Seattle. Dr. Zwerman is a graduate of the University of Illinois from which he received the degree of Doctor of Philosophy in Engineering last June.

L-O-F ANNOUNCES PROMOTION

E. W. Bradford, Minneapolis district sales manager of the Libby-Owens-Ford Glass Company, has been named district sales manager at Cincinnati. Mr. Bradford joined the L-O-F sales organization at Seattle, Wash., in 1928 and has been district sales manager at Minneapolis since 1932. Mr. Cornell Walbridge will succeed Mr. Bradford at Minneapolis. Mr. Walbridge was graduated from the University of Michigan and joined Libby-Owens-Ford in 1924 as a machine operator at Charleston, W. Va. After nine years in production, he was transferred to the company's Philadelphia office and remained there as a sales representative until his present promotion.

Howard Lewis of the company's home office at Toledo, Ohio, succeeds Mr. Walbridge at Philadelphia.

• Dr. Jar. Polivka has been appointed Research Associate of Civil Engineering at the Engineering Materials Laboratory of the University of California.

R. O. STILWELL

On November 21, at his home in Tarentum, Pa., there passed away, after a painful illness, Mr. R. O. Stilwell. Mr. Stilwell was formerly superintendent of the old Standard Plate Company at Butler and at his death was connected with the Pittsburgh Plate Glass Co. Thus, in the same week, the old Standard Plate Co. lost both its president and superintendent.

NEW WINDOWS FOR CHINA

(*Continued from page* 456)

The importance of building one furnace at a time is again stressed. Experience from the construction and operation of the first furnace will indicate modifications that may be necessary in the construction of the second one. One difficulty in the beginning of operation will be the supply of cullet, but it is proposed to have a number of small pot furnaces of simple construction for a preliminary melting of glass for this purpose. When regular operation has begun, the furnace will provide its own cullet.

Of the two departments which necessarily will operate the plant, the engineering department will be responsible for operation under technical control and the business management for operation on the basis of sales. It is estimated that five officials will be required for the business and technical control, together with about one hundred and sixty workmen. The labor item seems large to an American, but one must again remember that labor is cheap in China and that it replaces mechanical devices.

Economics

The question of investment and operating costs is most important. The initial investment for land, buildings, equipment, and machines and their installation will be about $185,000, taking local conditions into account. The daily overhead cost on the basis of 344 working days, including salaries, wages, office supplies, depreciation, plant insurance and liability insurance, as well as local taxes and repairs, will approximate $192. The daily cost of raw materials is estimated at $464, and the power cost $34. The grand total per day, therefore, is $690. Before the Japanese invasion, single strength window glass sold at $1.80 per box in China. Then, three Chinese dollars were the equivalent of one American dollar. Today, it takes fifteen Chinese dollars for an American dollar. This would seem to be an enormous disadvantage, but in reality it is not. Less than half (40 per cent) of the original investment consists of importations. Operating and sales costs both will be governed by local conditions. What is imported from America will cost five times as much as it formerly did. The laborer (and labor is the major factor in determining operating costs), still receives the same wages that he did before the war, when a Chinese dollar cost five times as much in American money as it does now; in other words, present operating costs are 80 per cent lower on the basis of American dollars than they were before the Japanese invasion. This seems like juggling; but we must remember that while the initial imports will go up fivefold in cost, the depreciation is not likely to be over 10 per cent as to future import requirements. Operation, on the other hand, should continue at 100 per cent, and at only 20 per cent of the pre-war cost.

Conclusion

On the basis of pre-war costs a plant has been proposed for China which an investment of $250,000 in American dollars, of which about $150,000 will go into equipment, $40,000 serve for construction and initial operation dur-

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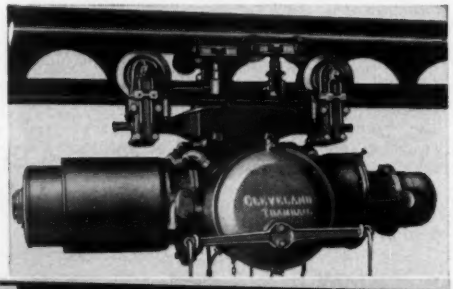

RIGHT: One ton Cleveland Tramrail electric hoist with hand-propelled carrier operating on Cleveland Tramrail arch beams.

Arch beams are used for applications where regular Cleveland Tramrail rail does not lend itself to long spans or where satisfactory superstructure cannot be provided. They consist of a wide flanged "T" member to which is welded a high-carbon long-wearing Tramrail rail with flat raised treads. The treads are hard and smooth. They eliminate troublesome peining which is common with systems subjected to severe service and continued rolling action of carriers.

Tramrail arch beams are an exclusive Cleveland Tramrail development and are available in six different depths to suit varying span conditions. They represent one of the many reasons why Cleveland Tramrail can serve you better.

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October was one of the most outstanding months in recent years for the glass industry. Production reached the highest point since August 1937. Payrolls were up, employment increased, exports set a new record and imports were considerably below their usual seasonal level. All branches of the industry shared in the increased domestic and foreign trade volume and there are indications that several more new records will be established before the year is completed.

According to GLASS INDUSTRY's Production Index, the total output of glass in October attained a value of approximately $33,000,000, the highest figure for any month since August 1937. This represents an increase of 20 per cent over September, and of 35 per cent over the same month of 1938. Total production for the first ten months of 1939 has exceeded a value of $260,000,000, which is 30 per cent better than 1938 and within 15 per cent of 1937.

GLASS INDUSTRY'S INDEX OF MONTHLY TRENDS
10 Months, January to October

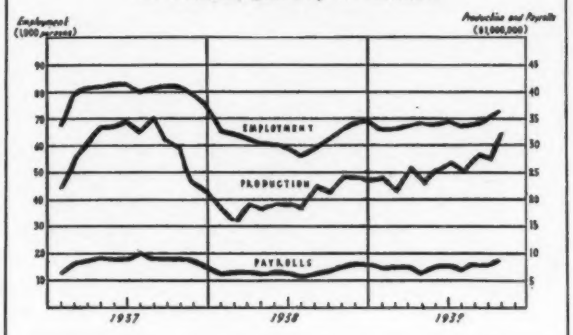
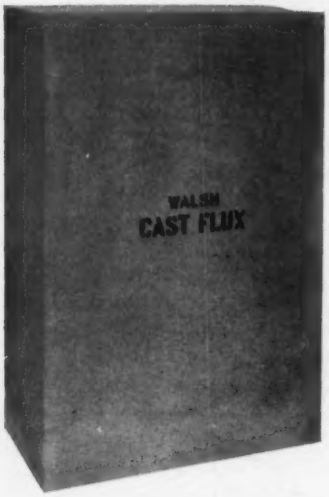


Plate Glass output during October totaled 18,369,000 square feet, according to the monthly report of the Plate Glass Manufacturers of America. This represented a 34 per cent increase over the previous month and a 43 per cent gain over October of last year. It was the largest monthly volume since June 1937. Ten months' figures of plate glass activity indicate that 1939 is running almost 80 per cent ahead of 1938 but is 37 per cent below the 1937 level.

Window Glass production during October amounted to 1,121,000 boxes, according to the monthly report of the Window Glass Manufacturers Association. This represented a 23 per cent increase over the previous month and a 75 per cent jump over October of last year. This activity reached the highest point in two years, exceeding all monthly totals since October 1937. During the first 10 months of 1939, window glass output exceeded the comparable 1938 volume by 78 per cent, but was 27 per cent less than the 1937 total.

Glass Container production during October totaled 4,891,000 gross which was 15 per cent ahead of September and 27 per cent more than October 1938, according to the Glass Container Association. This output was larger than in any previous month since August 1937 which indicates that for the first time monthly activity in this industry has run ahead of the industry's record year—1937. Shipments during October amounted to 4,471,000, which was about 12 per cent above the comparable periods of 1938 and 1937. The high production rate was necessary to take care of these shipments and to build up the low inventories resulting from the record shipments in September.

WALSH CAST-FLUX



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The excellent results obtained in numerous tanks melting various types of glass has definitely established the efficiency and economy of Walsh Cast-Flux blocks.

Walsh Cast-Flux has a dense, uniform structure; it is burned at higher temperatures, is thoroughly bonded and possesses a low coefficient of expansion.

Walsh Cast-Flux blocks meet the most rigid requirements for tanks operating at higher temperatures . . . they insure greater tonnage, higher quality glass, freedom from defects, longer life and maximum economy.

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Manufacturers of Refractories for the glass industry for over 50 years

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ing the first year, and $60,000 be available as a reserve for free capital.

On the basis of present conditions in China, the problem may be faced in two ways: A. American enterprise with an equipment investment of $150,000, and a fivefold return in China through the depreciation of the Chinese dollar and a consequent greater production return without a change in wages; B. Chinese investment with an initial importation cost of $150,000 (15 Chinese dollars per U. S. dollar) and a compensating return through operation at one-fifth of the pre-war cost (3 Chinese dollars per U. S. dollar) after the plant is available.

The American investor will, therefore, have a decided advantage on the basis of low operating costs after investment, while the Chinese investor would have a much greater initial investment and, therefore, would have to wait more years to get the return on his investment. A comparison of these conditions would seem to indicate, assuming the location of the plant in safe territory and under Chinese Governmental guarantee, that this project should prove attractive to American capital. The Chinese National Government welcomes foreign investments and promises full protection. While the Japanese have closed the front doors to foreign nations, the Chinese move westward promises to open the back doors. With a favorable Chinese exchange for the small replacement costs for imports and with the immense local downward drop in labor costs, the invitation for Americans to engage in this Chinese development looks attractive.

H-A MAKES FIRST VERMOUTH GLASS

What is said to be the first Vermouth glass ever made in this country has been made by the Hazel-Atlas Glass Company and will be introduced to the bars of New York City in December. The glass was designed by Count Theo Rossi, the "Vermouth King" and head of the famous Martini & Rossi Vermouth firm.

PAPER MILK BOTTLES (*Continued from page* 457)

Mr. Marcussen, who seemed to be the more widely quoted of the two big milk presidents, announced savings which the paper container would bring to the Borden Company would be as follows:

1. Elimination of the cost of broken bottles, which for this company averages 40,000 a day.
2. Does away with collecting and handling empty bottles, which now consumes 25 per cent of the driver's time, permitting the driver to devote full time to selling and delivering.
3. Makes bottle-washing machinery unnecessary, as well as its operation and maintenance. It takes 22 minutes to wash each bottle, says Mr. Marcussen.
4. Saves the waste in the refrigeration of deliveries, which for Borden amounts to 100,000 tons of ice per year. The paper containers can be insulated and refrigerated more efficiently and more economically.
5. Reduces operation and maintenance costs of delivery wagons, as they will carry lighter loads. Milk in fibre containers weighs 40 per cent less than glass, and requires 50 per cent less space.

If Borden and Sheffield want to bolt the milk bottle in New York, they have that privilege, of course, and time will tell whether or not the change was economically justified. But the milk bottle manufacturer does have a stake in seeing that the economics of glass and paper containers is fairly and truthfully presented, for its effect upon the milk bottle market generally, and their first step will be to make a thorough and impartial fact finding survey.

There is a great deal more to a change such as that announced in New York papers Nov. 7 and 8, than appeared in the advertisements or press releases. One thing completely overlooked was the outright failure of quart size paper containers to become popular in any market where they were tried. Another forgotten point was the excessively high cost of these containers as compared with the cost of re-usable glass bottles. The dairies of the country spent about $12,250,000 last year for new bottles and delivered more than 12 billion quarts of milk. Approximately 25 new bottles were bought in 1938 for every 1,000 quarts of milk delivered to the consumer. If paper had been substituted for glass, the container cost alone would have been approximately $160,000,000, over 13 times as much as was paid for new bottles. Accurate cost records show that the saving with one quart glass containers over one quart paper is from $.007 to $.008 per quart.

In the face of these facts, dairies could hardly have taken to paper unless a new factor had been introduced into the picture—the two-quart paper container. Whether it will do the trick is still a highly theoretical question. This is proved by experience with one quart paper containers. Nobody really knew how expensive this package was until it had been used long enough so that reliable cost figures could be determined.

There is absolutely no doubt that package cost will be millions of dollars greater with paper than with glass, whatever size is used. The New York dairies will have to find out if they can save the difference by re-vamping their systems of delivery. One step in this direction is a change from daily to every-other-day delivery. How will housewives take to that?

HIT OR MISS METHODS

• • • of ordering your alkalies do not result in savings

More often than not, such methods add a *hidden cost* that is hard to trace in the manufacture of your glass.

WHY should this be so? Suppose, for instance, that you do *not* obtain *all* the following advantages when you buy alkalies. A lack of any one of these *might* cost you money.

The right type of product for your job. Solvay Alkalies are made in various forms to meet specific manufacturing requirements. The Solvay Products Book gives you complete data on types and strengths of Solvay Products.

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• Libby-Owens-Ford Glass Co. has won for the second consecutive year the National Glass Distributors' Association award of merit for industrial accomplishment. The award was based on the company's promotion of safety plate glass and its nation-wide information service on new uses for glass.

EXHIBIT TO FEATURE CARDER'S WORK

The 39th Annual Exhibition of the New York Society of Ceramic Arts is being held at the Argent Galleries, 42 W. 57th Street, New York City, and will close December 9. Heretofore the exhibit has been confined to pottery, but this year glass as well as other forms of ceramic products will be included. Notable among the glass exhibits will be some of the work of Frederick Carder.

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS

FOR THE GLASS INDUSTRY

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IMPROVING THE STRENGTH OF GLASS CONTAINERS

(*Continued from page* 447)

this ideal distribution can be obtained by the machine operator in practice (and other fabrication irregularities eliminated). That is not as big an "if" as it might seem. Fabrication machines, blank mold design, and operating technique, are constantly being improved.

Weight may be reduced and the strength may be increased by eliminating dead weight in the form of thick bases and corners, by employment of lower surface to volume ratio shapes, and by generous use of double curvatures, without decreasing the wall thickness. Weight may also be reduced by decreasing the wall thickness. Sometimes both are done. If the wall thickness is radically decreased, then there is grave danger that the strength will be impaired (radical shape changes excepted) unless compensating improvements in the quality of the distribution are made simultaneously. It is in such instances that lighter weight is vitally dependent upon the attainment of ideal distribution. Fortunately, it is just those rounded shapes and bulging double curvatures that increase strength and decrease weight that are also the joy of the mold shop and the machine operator. These are the shapes that are naturally adapted to the attainment of ideal distribution in practice.

• A paper, "Sealing Platinum to Pyrex Glass," appears in the September 1939 issue of *Rev. Scientific Instruments*, Cornell University. Edward Wichers and C. P. Saylor are the authors.

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ISCO CARBONATE OF POTASH

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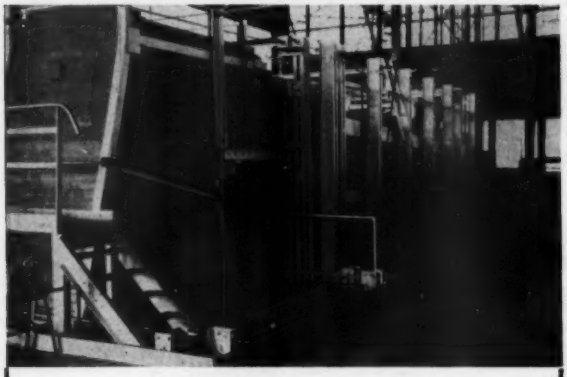

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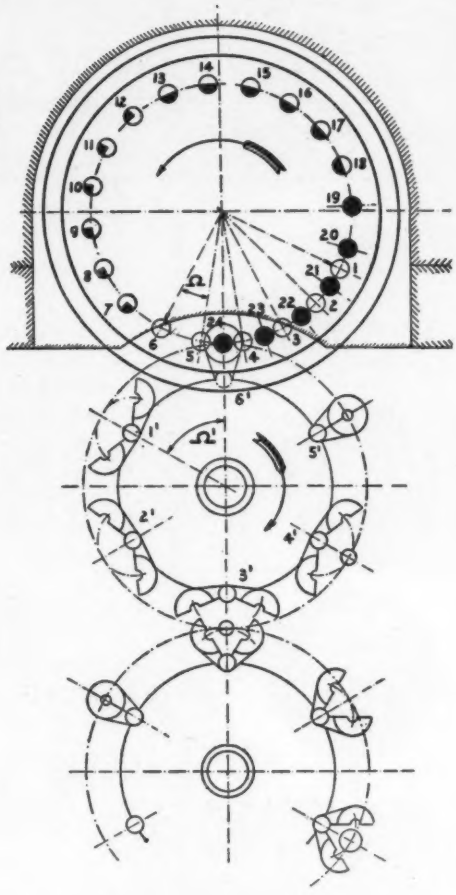
assures quality and economy

From installation through to actual production operations the Roirant "A 6" has been proved to be the most economical and efficient suction type bottle machine. The development of the intermittent motion revolving pot located within the furnace enables the Roirant "A 6" to offer many advantages; a few are as follows:

1. Glass surface and parison mould are immobile at moment of suction—insuring greater homogeneity of glass.
2. Due to immobility of machine and revolving pot diameter of the latter is independent of suction time—hence pot diameter has been considerably reduced.
3. This reduction in pot diameter makes possible installation of the revolving pot within the melting tank. The metal therefore is continuously exposed to the regular and most suitable working temperature of the refining tank—the desirable condition of the glass normally destroyed through repeated suctions is re-established at constant intervals. (See illustration).
4. Utilizing the melting tank heat volume to maintain the working temperature assures important savings in fuel consumption. Inclusion of revolving pot in the tank eliminates complicated installation costs.
5. Highest efficiency in maintaining working temperature of glass in pot is obtained through control of relative speed ratios of combined machine and revolving pot. The latter makes only a small fraction of rotation to each complete revolution of the parison mould table.



Position of the 4 × 6 = 24 drawing spots 1 to 24 in the revolving pot after four complete revolutions of the parison mould table

- ○ suction spots 1 to 6 – first revolution of the parison mould table 2
- ◔ suction spots 7 to 12 – second revolution of the parison mould table 2
- ◒ suction spots 13 to 18 – third revolution of the parison mould table 2
- ● suction spots 19 to 24 – fourth revolution of the parison mould table 2

etc.

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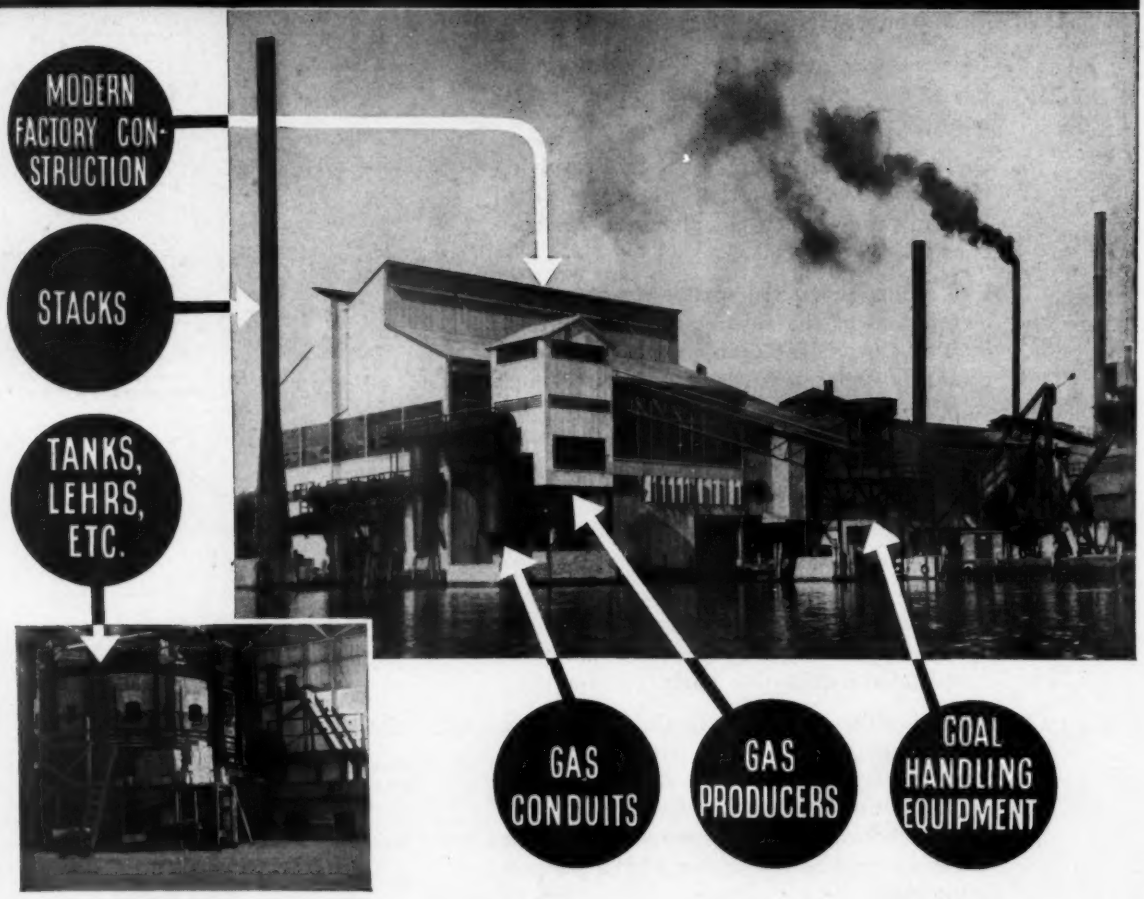

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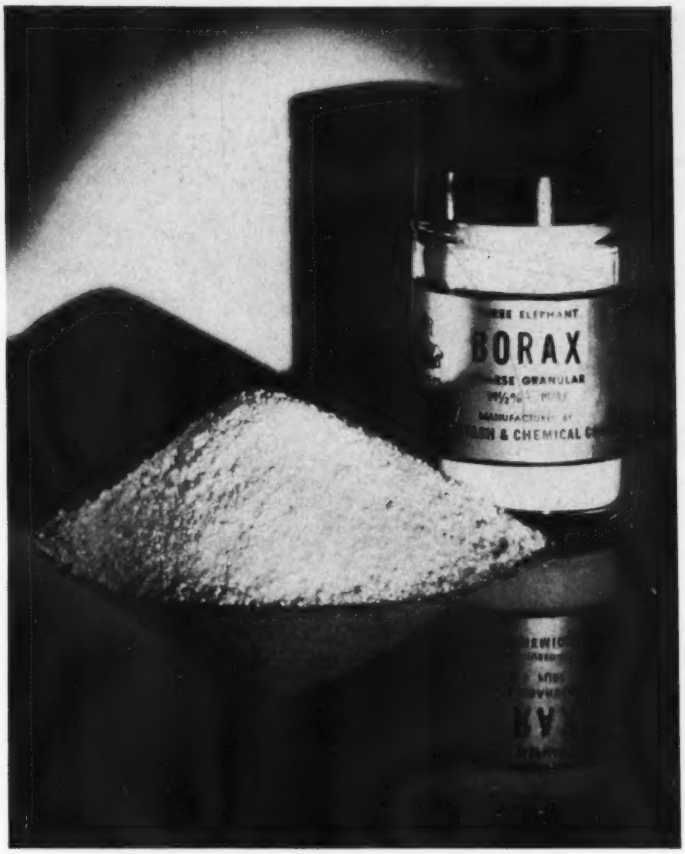

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It facilitates the melting process to an extent which is apparent in lower production costs.

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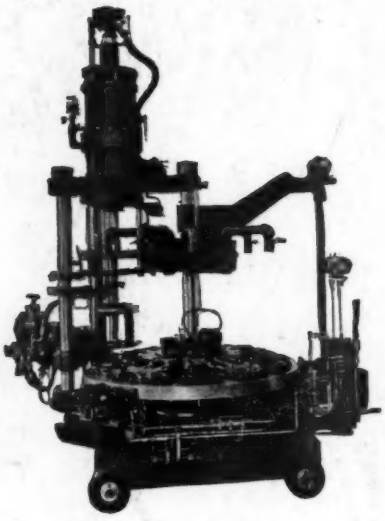

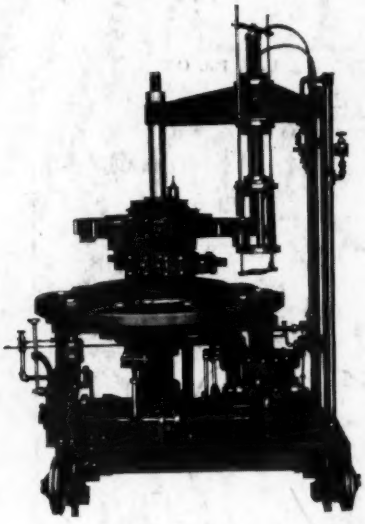

PRESSES

Designed and manufactured exclusively for pressed glassware, accommodating solid (block) molds, as well as open and shut (jointed) molds. Tumblers, jellies, nappies, glass block, tableware, stemware and ointments are some of the many items that can be made on these machines.

Let us furnish you with complete information relative to speed and how economical your glassware can be made on these modern presses . . . no obligation whatsoever.

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